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An effective AutoCAD curriculum for the high school student

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**AN EFFECTIVE AUTOCAD CURRICULUM
FOR THE HIGH SCHOOL STUDENT**

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education: Vocational

By

William C. Brown

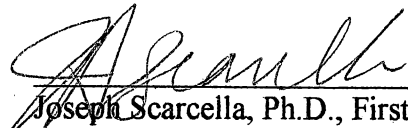
June 1999

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Abstract

The instruction of computer assisted drafting (CAD) in the high school classroom presents unique problems and challenges that typical colleges, technical schools, and industry do not have to address. Issues such as cross curriculum instruction, beginning and advanced students in the same class, several courses in the same room, CAD and manual drafting taught concurrently, shorter class periods, and limited resources. In addition, curriculum must meet the California State Frameworks for Industrial Education in the area of Visual Communication: Drafting.

The objective of the curriculum will be to expose students to CAD. Students will be proficient enough with the CAD software to be able to visually communicate their ideas, using industry standards. The most popular CAD software for the microcomputer presently is AutoCAD, rationalizing my use of it for the project. The curriculum will be set up so students will need a minimum of teacher lecture/demonstration of commands. The sequence of commands learned will be carefully and thoughtfully planned. Students will be expected to learn at their own pace, in an environment of peers who are both more and less proficient using CAD than themselves. The teacher's role will be predominantly that of facilitator, however teacher demonstrations in critical areas will be essential to speeding up the learning process for most students.

Functions of CAD that integrate with other high school subject areas will be emphasized. For example: the Cartesian coordinate system on the CAD screen and graphing using the x-y axis in Algebra.

The project will focus on the high school student. Traditional textbooks and workbooks do a satisfactory job of providing terminology tests and reference material. The texts do not give enough age-appropriate drawing problems. The texts also frustrate students with their extensive explanation of topics/commands high school students do not need to be exposed to yet.

Assessment of student work will be performance-based. Student work can be evaluated on diskettes or plotted drawings or a combination of both.

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Chapter One: Background

Introduction

The content of Chapter One is an overview of the computer assisted drafting (CAD) curriculum project. The context of the problem is introduced, followed by the purpose and significance of the project. Next, the limitations and the de-limitations that apply to the project are reviewed. A definition of terms is presented at the end of the project.

Context of the Problem

Industry's change from manual drafting to CAD is significant. CAD has become the cornerstone of visual communication in industry, and has become the rule rather than the exception, when choosing a media to visually communicate.

Teaching high school students in today's advanced and diverse technologies is becoming increasingly complicated. Typical high school "drafting" classes offer several areas of emphasis such as engineering drafting, architecture, technical illustration, and model making.

The modern high school drafting and architecture course's main objectives are to train students to utilize manual and computer-aided drafting techniques to industry standards and to visually communicate within industry. Current textbooks used for training adults, whether manual or CAD, many times do not meet the needs of the typical high school drafting student. Most CAD textbooks do not incorporate age-appropriate engineering drawings or problems with basic CAD exercises. The "industry texts" are comprehensive, complicated reference manuals, written at the college level, with inappropriate drawing problems and exercises for high school-level students. The CAD

texts are written with the goal of software instruction, not visual communication using CAD as a tool to communicate. Typical CAD texts also do not take into account the cross-curricular instructional objectives of high school education, or meet the needs of students with lower reading comprehension skills than the typical draftsman.

High school drafting instructors who teach CAD have been left to design an appropriate curriculum on their own to meet the needs of their students.

Purpose of the Project

The purpose of the project is to develop a workbook that incorporates age-appropriate drawing problems, design problems, and the critical commands of CAD. A teacher with 35 students cannot provide extensive one-on-one instruction, so the workbook will be designed to eliminate common problems and questions directed toward the teacher. The workbook will be designed to meet the needs of combination classes, with exercises from several different disciplines. Reducing the number of texts required to effectively communicate lessons will reduce the amount of money dedicated to books and allow distribution to other important areas (like new software and hardware). The workbook will be designed so changes (all too frequent) in revisions of AutoCAD will not significantly effect the workbook. The workbook will be formatted to allow students to work at their own pace.

Significance of the Project

High school drafting teachers generally require several resources for teaching Design Drafting or Architectural Drafting and Design using AutoCAD. The workbook will incorporate drawings from various textbooks that challenge high school students at

various levels. Drawings that promote confusion and misrepresentation of ANSI standards will not be in the manual.

This resource will help students meet performance objectives as outlined by the California State Frameworks for Visual Communication-Drafting. The workbook will help decrease the amount of time that the teacher spends with each drafting student explaining common CAD commands and errors. Decreased teacher time spent on software instruction should increase the time allotted for the drafting teacher to teach visual communication concepts such as: Orthographic projection, dimensioning techniques and standards, floor plan design criteria, product design, etc. Students will progress through the software system while learning current drafting and architectural techniques.

Evaluation of completed student work will be a function of the sequence of problems selected. Beginner-level drawings will be teamed with beginner-level CAD commands. For example, a one-view sheet metal pattern would incorporate basic CAD commands like “line”, “offset”, “circle”, and “chamfer”. This strategy would allow students to produce drawings quickly, while learning CAD commands without being overwhelmed by the complexity of the software system. Finished drawing problems that incorporated critical CAD commands, and cross-curricular instruction will be available for the teacher to critique and “redline”. It is important to remember that CAD is a tool for visual communication. The tools will change (quickly) over time, but visual communication techniques will remain predominantly the same over time.

Delimitations

The target audience for this project is high school students enrolled in a combination CAD/Drafting/Architecture class. The curriculum is not written for the college level student, but could be used in introductory level classes at the college or technical school level.

Limitations

The project will be designed to accompany standard texts and CAD manuals, not to replace them. AutoCAD revision 12 is the software the project will be designed around, so schools using different revisions, or changing revisions, will have to make adjustments to the “commands” portion of the project.

Definition of Terms

The following terms are defined as they apply to this project:

ANSI: The abbreviation for the American National Standards Institute (Spencer, 1995).

AutoCAD: Computer-Aided Drafting (CAD) software developed by Autodesk (Shumaker, 1994).

Command: A code that directs the computer to perform a particular operation or sequence of operations (Shumaker, 1994).

Communication: The exchange of ideas, messages, or information (California department of education, 1996). Computer assisted drafting (CAD): The use of computers and peripheral devices to aid in the documentation for design projects (Wallach, 1989).

Cross-curricular instruction: The integration of one subject matter into one or more other subject matters (California department of education, 1996).

Framework: A dynamic document providing direction and coherence for collaborative program and curriculum development (California department of education, 1996).

Hardware: The tools available to users of CAD for input, processing, and output (Wallach, 1989).

Revision: A change from the previous model (Shumaker, 1994).

Software: A set of programs, procedures, rules, and possibly associated documentation concerned with the operation of a CAD system (Wallach, 1989).

Organization of the Project

This project is divided into five chapters. Chapter One provides an introduction to the context of the problem, purpose of the project, significance of the project, limitations and delimitations, and definition of terms. Chapter Two consists of a review of the literature. Chapter Three outlines the population to be served and the project design. Chapter four supplies the budget information. Chapter Five presents the conclusions and recommendations generated from the project. The project and references follow Chapter Five.

Teaching high school students in today's advanced and diverse technologies is becoming increasingly complicated. The purpose of the project is to develop a workbook that incorporates age-appropriate drawing problems, design problems, and the critical commands of CAD specifically for high school students. By using the workbook and the drafting teacher as a resource, students will progress through the software system (AutoCAD) while learning current drafting and architectural techniques.

Chapter Two: Review of the Literature

Introduction

Chapter Two consists of a discussion of the relevant literature. The history of computer-aided drafting (CAD), industry's transformation from manual drafting to CAD, hardware and software, and an introduction to the American National Standards Institute's (ANSI) dimensioning standards.

History of CAD

Early drafters measured distances with crude scales and made freehand sketches. Later drafters used simple wooden straightedges as an aid to drawing. For centuries drafters used T-squares, triangles, and compasses to draw more accurate lines, arcs, and circles. Later, the development of the drafting machine and parallel slide systems enabled drafters to draw much faster and with greater accuracy. Today, computer systems give drafters the ability to literally draw at the speed of light.

Computer systems designed to perform drafting functions are known as computer-aided drafting systems (CAD). Computer systems with the capacity to graphically solve more complex design problems are called computer-aided drafting and design systems (CADD). Drafters interact with CAD or CADD systems to rapidly produced drawings that are extremely accurate, consistent, and easily changeable.

Early CAD systems of the '60s, like all early computer systems, were extremely large, expensive, complicated, and difficult to use. Some systems filled entire rooms and cost millions of dollars. Today's personal computer systems are smaller, faster, less expensive, easier to use, and can perform more complex tasks. These improvements and

changes were made possible by the development and continued refinement of the integrated circuit chip (IC). This development led to enormous expansion in the use of CAD systems in all phases of drafting, design, engineering, manufacturing, and construction. The developmental process continues with breakthroughs in system size, speed, accuracy, and ease-of-use (Wallach, 1989).

Industry Transformation from Manual Drafting to CAD

The rapid growth of computer-aided drafting on the microcomputer (micro-CAD) is relatively new, but micro-CAD itself is not. There have been micro-CAD systems in use since the late 1970's. However, these earlier systems were seriously lacking in real design and drafting capabilities. Early microcomputers had neither the processing power nor the graphic capabilities needed in CAD. Consequently, micro-CAD got off to a bad start. Early micro-CAD systems were slow, limited to only the most basic two-dimensional drafting tasks, and able to produce documentation of only marginal quality. Such systems were thought of as being "toys", and for the most part rejected by the private sector. For the most part, the problems associated with early micro-CAD systems grew out of the problems with early microcomputers. Before micro-CAD could become a real alternative for companies that wished to convert to CAD but could not afford traditional systems, two things had happened.

1. Development of the microcomputer had to reach the point where more memory and processing power were available.
2. The element of the microcomputer had to reach the point where better graphic capabilities were available.

By the early 1980s both of the developments had taken place. The powerful 16-bit microcomputers were available. Microcomputers of 512K bytes of RAM became commonplace. Dual disk drive configurations or a combination hard disk with one floppy disk drive also became the norm. High-resolution color monitors became readily available at affordable prices. These developments paved the way for the acceptance of micro-CAD (Chalk, 1994, p.397).

Hardware and Software

The physical pieces of equipment used in computer-aided drafting and design are referred to as hardware. The microcomputer is the main component and is accompanied by several other devices called peripherals. The specific components included in a CAD workstation are the computer, monitor, keyboard, pointing device, storage device, printer, and plotter.

The “computer” contains the central processing unit (CPU), memory, disk drive(s), and hard disk drives. The CPU is the heart of the computer and handles all of the system’s calculations. They are generally graded by processing speed in megahertz (MHz). Today’s fastest microcomputer CPU “run” at 333 MHz. The CPU also contains “cards” that control the components that will be attached to the computer. Video display (monitor), mouse ports, keyboard ports, extra memory, sound, and CDROM can have cards placed in the CPU (Shumaker, 1996). It is advantageous to use the fastest CPU and the most memory (RAM) that is affordable, to run AutoCAD optimally. Sites may consider upgrading the video RAM to give better video results.

The “monitor” is the output or display device that resembles a small TV. The monitor is “graded” by size and resolution. Monitors are generally available in sizes from 14” to 21”, but can be larger (Shumaker, 1996). Larger monitors reduce eye-strain for AutoCAD users. Bigger is better! Nearly all monitors are now color-compatible. Clarity of the monitor picture is controlled by “resolution”. Resolution refers to the number of dots on the screen; The more dots, the closer they are to each other, the clearer the picture. A monitor with a resolution of 640 X 480 would show objects on the screen as more “jagged” than a monitor with a resolution of 1024 X 768. Graphics applications like AutoCAD generally take advantage of monitors with high resolutions to project their images clearly.

The “keyboard” is generally the most used input device at the workstation. Commands can be typed in from the keyboard to initiate the CPU to process information. Function keys on the keyboard (F1, F2...) can be programmed to perform specific, time saving commands (Shumaker, 1996). Ergonomic keyboards are available and may be a welcome system addition for users who input AutoCAD commands predominantly with the keyboard.

The “pointing device” allows the user to select point locations and commands from a screen or a digitizer tablet menu, by moving the cursor or crosshairs on the screen. Common pointing devices are the multi-button puck, pen-shaped stylus, mouse, and trackball (Shumaker, 1996). Mice are quality, inexpensive pointing device solutions for the classroom. It is probably best to spend classroom system money other places than expensive digitizers.

The “storage device” in the computer will be a hard drive, a floppy drive(s), and perhaps a “zip-drive”. Programs are stored on the hard drive (e.g. AutoCAD, Windows 95, Microsoft Word). Drawings can be stored on any of the previously mentioned drives. AutoCAD drawings are getting larger and larger as its options increase. Most companies and schools save their drawings on the hard drive and “back-up” the data with floppy disks. Portable or internal zip drives provide an affordable option to the hard drive and floppy drive for storing drawing files. Other technologies for file storage and management such as optical drives and network hubs are available for sites with loftier needs and budgets.

The “printer” and “plotter” are output devices that produce “hard copies” of the CAD drawing. A good choice for the classroom is an inkjet plotter. Inkjet plotters provide affordable, high quality hard copies of CAD drawings. They are faster and more reliable than the old pen plotters (the pen plotter pens would clog frequently). The plotter can be networked to several computers or setup with a single computer as a plotter station.

The History of AutoCAD, Operating Systems, and the Microcomputer

AutoCAD was chosen as the CAD software for the project because it is the predominantly utilized software in industry (that use microcomputers for CAD). The increased use of CAD, specifically AutoCAD, has followed a parallel path with the development and increased performance of Intel’s microchips and the Microsoft’s operating systems. A basic chronology of AutoCAD’s development and key functions

along with the microcomputer's development and computer operating system's development are as follows:

- 1982- Autodesk, Inc incorporated with \$59,030 capital.
- 1982- AutoCAD v1.0 (\$1,000) runs on S-100 Z80 systems.
- 1983- Compaq created- clone wars begin.
- 1983- DOS 3.0
- 1983- AutoCAD v1.3 (plotter support) and v1.4 with ADE-1
- 1984- Apple Macintosh
- 1984- AutoCAD 2.0 (OSNAPS and user defined layers).
- 1984- AutoCAD seats surpass 10,000.
- 1985- Intel 80386 Processor introduced.
- 1985- AutoCAD 2.1 and 2.18 ships with Autolisp.
- 1986- AutoCAD 2.5 (ships with hardware locks).
- 1986- AutoCAD up to 50,000 copies sold.
- 1987- AutoCAD 2.6 (associative dimensioning).
- 1987- OS/2 1.0 and MS-DOS 3.3
- 1987- Windows 2.0
- 1987- AutoCAD 9.0 (Pull-down menus, dialog boxes).
- 1988- AutoCAD up to 100,000 copies sold.
- 1988- MS-DOS 4.01
- 1988- AutoCAD 10 (3-D, UCS, DXF)
- 1989- AutoCAD 10 for the Macintosh.
- 1989- Intel 80486 Processor introduced.
- 1989- AutoCAD acquires lower end CAD software producer Generic Software and GenericCADD.
- 1989- 600 third-party applications available for AutoCAD.
- 1990- Windows 3.0
- 1990- AutoCAD r11 (paper space, xrefs, network support)
- 1990- Autodesk customer base tops 600,000- 265,000 on AutoCAD, 215,000 on GenericCADD, and 150,000 on Autosketch.
- 1991- MS-DOS 5.0
- 1991- Autodesk customer base tops 1,000,000.
- 1992- Windows 3.1
- 1992- AutoCAD r12 (entity grips)
- 1993- MS-DOS 6.0
- 1993- Windows NT
- 1993- AutoCAD LT (\$495)
- 1994- IBM OS/2 Warp
- 1994- Autodesk sells 1,000,000 copy of AutoCAD.
- 1994- AutoCAD r13 (windows interface, ACIS-based 3-D commands)

- 1995- Windows 95 introduced.
 - 1995- Pentium Pro introduced.
 - 1995- AutoCAD LT R2.
 - 1996- Softdesk acquired by Autodesk.
 - 1996- GenericCADD discontinued.
 - 1997- AutoCAD R14 (\$3,750 list)(raster, faster).
 - 1997- Pentium II processor running as fast as 333 Mhz.
- (Cadalyst: The autocad authority. March, 1998, pg. 49-72)

Introduction to ANSI Standards for Drafting

This highly competitive, industrial world requires that full advantage be taken of all methods that help improve efficiency and reduce product cost. Application of dimensions and tolerances according to the current standards permits clearer definition of requirements that was ever possible before. Current standards define methods for increasing tolerance zones without reducing product quality and design function. Improving drawing clarity and increasing allowable tolerances are the two means for improving competitive position.

Knowledge of dimensioning and tolerancing methods helps to ensure clearer application of part requirements. Tolerances can be maximized through careful dimensioning and tolerancing calculations and application of the calculated values through proper utilization of standardized methods.

A majority of commercial and military industries require engineers and drafters to be knowledgeable in proper dimensioning and tolerancing methods. Machinists, inspectors, and industrial engineers are also required to understand dimensions and tolerances since they must work to the drawings created by the engineers and drafters.

The guidelines for consistent and clear application of dimensions and tolerances are defined by the standards of the American National Standards Institute, written by the American Society of Mechanical Engineers (ASME). The number of companies requiring compliance with national standards is continually growing.

Proper application of dimensions and tolerances is an important part of providing complete documentation of product requirements. ASME Y14.5M-1994 is the authoritative document for defining the dimensioning and tolerancing symbols and application methods (Madsen, 1996).

A knowledge of the history of computer-aided drafting (specifically AutoCAD) and awareness of industry's transformation from manual drafting to CAD is necessary to help in the planning for future CAD hardware and software needs. For example, knowing that AutoCAD's most impressive changes have historically occurred in the even numbered releases may assist in software purchasing decisions. History also shows us CAD is growing rapidly, with no slowdown in sight.

Chapter Three: Methodology

Introduction

In order to meet the needs of high school drafting students, materials will be gathered from several sources. Traditional drafting textbooks and workbooks, CAD workbooks, industry journals, industry standards manuals, state model curriculum standards/frameworks, handouts collected from other drafting teachers, and self-made exercises. The combination of these materials will be sufficient to create the CAD manual for high school students without having to “re-invent the wheel”.

Reference Materials

Research will be performed to identify the textbook needs of high school CAD teachers. A questionnaire will be given to all drafting teachers attending the 1998 CITEA conference, specifically the California Drafting Technology Consortium (CDTC) luncheon. The results of the questionnaire will effect the choice of software and materials for the manual.

The questionnaire will give me insight on software revision choice(s), drafting subject(s) of concentration, an upgrading chronology, information on CAD access for high school students, and of course a knowledge that there is a demand for what I plan to produce: “An Effective AutoCAD Curriculum for the High School Student”.

Industry journals to be used for the manual will be “Cadence”, “Cadalyt”, and “Techniques”. “Cadalyt” is an Autodesk/AutoCAD “vehicle” devoted predominantly to AutoCAD users. “Cadence” is the largest independent CAD magazine and covers CAD products and techniques in general. “Techniques” is a vocational education journal that

will assist in the education issues such as evaluation, assessment, and cross-curricular instruction.

The traditional drafting textbooks and workbooks most drafting teachers use do a good job of providing drawing problems of varying difficulty for the high school drafting students. Many of the drawing exercises will be (carefully) selected from my selection of drafting textbooks and workbooks. The texts do however, fall short in two critical areas: their explanation of how to use CAD to draw the problems efficiently and drawing problems are not presented to industry standards.

CAD workbooks most drafting teachers use do a good job of providing software training and CAD techniques to teach students to draw more productively. The CAD manuals cover (nearly) every command the software has to offer. They are excellent reference manuals for high school students. The software commands and techniques for the CAD manual for high school students will come from CAD workbooks. The CAD workbooks are too comprehensive for the typical high school student and inundate the high school student with commands they do not need to know this early in their drafting training. Incorporating the commands the students need to know to effectively visually communicate, using CAD as a tool, will be the goal of the manual.

ANSI Standards

Books and manuals that reflect the current ANSI Y14.5M-1996 standards will be used. These standards manuals will also be used to assist in updating drawing problems from the textbooks (often dimensioned poorly and dimensioned to past, obsolete

standards). With CAD now the principal means of drafting, knowing the current standards for drafting has become even more important than in the past.

High school students have more diverse needs than professional drafters, college students, or technical school students. The high schools students require a diverse, integrated curriculum. Writing skills are taught in English, Social Studies, Math, Science, and other curricular areas. Math skills are taught in Math but also in Science, Business, and Drafting (just to name a few). A good drafting curriculum utilizes cross-curricular instruction in its development and in its implementation. Using the California State Frameworks for Industrial and Technology Education, the manual will have integrated into it subjects such as Math, Writing, Art, Science, and Industrial Education.

Before committing a great deal of work to producing a document that I believe there is a demand for, I felt it necessary to consult a large number of my fellow teachers. Cornering them at a “professional conference” with a detailed questionnaire was my strategy. Reference material collection was a tedious task, as there are dozens of “current” drafting books with varying focuses and levels. Many of the books were poorly written as well as simply incorrect when explaining current industry standards. A great amount of time was spent pulling the “quality” information from the many texts for integration into the manual.

Chapter Four: Financial Considerations

Introduction

The primary reason this CAD workbook will be developed is to address the textbook needs of the high school drafting student without having to invest in multiple textbooks. To visually communicate key concepts to the drafting student, the textbook must include color pictures of the graphic interface of AutoCAD integrated with the spatial visualization skills of drafting. Additionally, the functions of AutoCAD utilize color to organize information (through layers, linetypes, and coding).

The 150 page workbook will require high-resolution color copies at \$.12 for each page. The workbook will require hardcover binding to resist student wear, at a cost of \$12.00 per book. Total cost per book will be \$30.00.

Hardware

When choosing hardware and software, consider the following:

1. Schools are not money-making operations.
2. CAD drafting students do not have jobs (yet) that emphasize their productivity.
3. A high-budget, high school CAD drafting station does not have to be equivalent to a high-budget station used in industry.
4. CAD is a tool to teach, learn and apply visual communication.
5. How much money do you have and how many students do you want to serve with that money?

Several hardware systems can be used for CAD instruction. Technology changes frequently in both hardware and software, but historically prices have stayed reasonably stable. The hardware systems described below address hardware and software systems for programs with (relatively) low, medium, and high budgets. This information should be used only as a guide for comparison of systems in choosing a direction for a new program.

Low Budget

Software: Two or more revisions behind the current revision. \$250.00 per station. Many high school programs cannot afford to stay up to the current release, especially with the lack of site licenses from Autodesk.

Monitor: 14 or 15 inch color.

RAM: Lowest allowable by software. You may experience an occasional software crash.

Hard Drive: Large enough to store student files, CAD program, operating system, word processing software, but not much else.

Speed: Minimum speed requirement set by software. Program will run slow but effectively.

Cost: \$500.00 to \$600.00 per station

Medium Budget

Software: One revision behind the current revision. Educational pricing is available at significant savings over the current revision. \$500 per station and upgradable to the next revision (when it is one revision behind) for about \$250.

Monitor: 15 inch color or low end 17 inch color.

RAM: About half the RAM of the newest CPU's on the market. This should allow for plenty of memory for student use, without crashes.

Hard Drive: About $\frac{1}{4}$ to $\frac{1}{2}$ the space of the newest CPU's on the market. This will be large enough to store several large programs along with the CAD program, student files, and operating system.

Speed: Two levels lower than the newest CPU's on the market. This should be fast enough to run CAD in a high school setting with great results, unless 3-D graphics or significant multi-tasking is being utilized.

Cost: \$900.00 to \$1100.00 per station.

High Budget

Software: The current revision. Cost is about \$1200 to \$1400 per station (educational pricing).

Monitor: 17 inch color.

RAM: Recommended RAM for latest revision of CAD software.

Hard Drive: Unless you plan on saving graphic files to a network server, a large hard drive capable of holding many large graphic files in addition to AutoCAD and "office programs" will be necessary.

Speed: One level lower than the latest, newest CPU on the market. This will run the latest revision of CAD fast and effectively in a high school setting and you will be the envy of all your colleagues.

Cost: \$1600 to \$2200.

Each school will have its unique considerations when deciding on hardware and software. Prices have historically stayed fairly consistent while product capability has increased exponentially. It is a true dilemma to attempt to stay “current” yet serve as many students as possible with the money accessible for technology. Industry policy imitation does not assist in the decision because its objectives are more financially based (productivity verses capital outlay) than the typical public school. Educators must remember their main objective is to meet the comprehensive educational needs of all their students.

Chapter Five: Summary

Introduction

Textbooks presently on the market do not, by themselves meet the needs of high school level CAD drafting students. Based on data obtained from questioning drafting teachers across the state of California, a need for better high school CAD drafting texts exists. The purpose of this project is to develop a cost-effective workbook for high school students that incorporates age-appropriate drawing problems, design problems, and the critical commands of CAD.

This resource will help students to meet performance objectives as outlined by the California State Frameworks for Visual Communication-Drafting. With the new dominance of computer assisted drafting as the preferred tool for drafting, students have been given the additional responsibility of being proficient in the use of the CAD software to make themselves marketable to industry. Students are also expected to be aware of industry standards for drafting; the more they know, the more value they have in the workplace.

It must be remembered that computer assisted drafting (CAD) is a tool for visual communication. The high school's primary responsibility is to teach design techniques and principles, communication techniques and principles, and then the software tool to do it. By the time the students are employed by industry, several software revisions will have passed, but the communication standards will be basically the same.

The manual is designed to accompany standard texts and especially to accompany CAD texts. The CAD texts are comprehensive in their coverage of the software

commands and features. The manual is not designed to be a reference text. The CAD texts are revision specific and must be re-written after each revision change. The manual will be written so it does not have to be changed after each revision change, however as software changes more dramatically, re-writes of the manual will follow.

Project Development

The challenge of creating drawing problems that addressed problem solving, industry standards, AutoCAD commands, and incorporated cross-curricular instruction was challenging. It was difficult to design the problem so that the student had to creatively solve the problem, with a limited amount of hints, and still apply the correct standards. It was also difficult to decide which order to introduce each AutoCAD command. The student needed a working knowledge of each command to be used for a drawing problem, before the problem could be solved. Concessions had to be made, such as just telling them how to use a command (with explanation to follow).

A large challenge in preparing the manual was the importing of graphics. The saying “a picture tells a thousand words” certainly applied to this project. Although student comprehension of technical literature (through practice) was a major goal of the manual, some graphics were necessary for effective communication.

APPENDIX A: QUESTIONNAIRE RESULTS

1. What Software and Revision do you use in your classroom?

N=33 Respondents

"AutoCAD"		xx	2
AutoCAD	R9		0
	R10	xxxxxxx	7
	R11	x	1
	R12	xxxxxxxxxxxxxxxxx	14
	R13	xxxxxxxxx	9
	R14	xxxxxxxxx	9
	LT	xxx	3
	12 LT	x	1
3D HOME ARCH		xx	2
VERSACAD 8		xxx	3
MASTERCAM		x	1
MICROSTATION		x	1
CADKEY		xx	2
AUTOSKETCH		xx	2
TURBOCAD		x	1
3D STUDIO MAX		x	1
DATA CAD		x	1
PEN DRAFTER		x	1

1a. Multiple software revisions or programs in their drafting program?

N=33 Respondents

YES	NO
xxxxxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxx
N=19	N=14

AutoCAD is the predominant software used, however teachers are using several revisions - many times in the same room. It is not practical to write the workbook to a specific revision of AutoCAD, but reasonable to focus on AutoCAD because of its market dominance. Writing manual to older versions is valid based on usage statistics.

2. How many levels of subjects do you offer in a single period?

(EX: DRAFT A, ARCH A, ARCH B)

N=33 Responses

8	5	6	3	3	7	7	2	6	4	4
8	3	1	2	4	2	7	5	6	4	5
4	2	4	4	6	8	7	4	1	7	6

Courses have a mean average of 5.5 levels of students per program. The manual will need to meet the needs of lower/beginning students as well as higher level students.

3. How many texts and supplemental texts do you use in your classroom?

N=32 Responses

4	3	6	2	6	3	6	3
3	4	3	4	0	2	2	2
2	4	4	4	2	2	5	2
0	1	6	6	3	0	1	0

3.3 texts and supplemental texts per program.

4. Do you know of any textbooks for CAD that are specifically designed for high school students' needs? If so, please list the name(s) and author(s).

N=33 Responses

* Applying Autocad - Delmar

* Drafting w/ Autocad LT - Chowenhill - Wallach

* Fundamentals of Drafting with Autocad LT-ITP

* Autocad and its Applications R14 - Goodheart Wilcox

* Applying Autocad - Wohlers

* Cad Key

* “Unknown Title: Masden - Goodheart Wilcox

*26 “NO” answers

5. Have you upgraded in the last 5 years? If so, how many times?

N=32 Responses.

1	4	1	0	1	0	0	3
4	4	1	0	3	2	0	0
1	0	1	1	1	4	0	2
0	2	1	3	2	5	1	1

62% had zero or one upgrade in the last 5 years. The mean was 1.8 upgrades per program every five years.

6. Do you think typical CAD manuals could be reformatted to better meet the needs of your high school students?

N=34 Responses

Yes 29

No 02

No answer 03

7. How many computers do you have in your classroom?

N=33

20	25	16	12	19	15	24	15	46	30	28
30	0	19	33	25	18	50	27	35	36	7
18	27	149	20	15	34	13	28	12	6	10

Mean average is 22 computers per classroom.

8. How many manual drafting machines do you have in your classroom?

N=33 Responses

29	37	0	24	28	24	26	25	15	28	34
28	12	30	20	12	28	28	24	24	0	30
30	24	0	1	22	12	0	31	36	30	35

Mean average of manual drafting machines per class is 22.

9. Does your district give cross-curricular credit for any of the Industrial Education courses offered at your school? If so, what are the name(s) of the course(s) and the name of your district?

N=30 Responses

YES

Arch II - Fine Arts

CAD Geometry - Math

Arch Design - Fine Arts - Oxnard Union High School District

Mechanical Drafting - Math

Mechanical Drafting – Math - Antioch Unified School District

2 years Industrial Technology - Yorba Linda Unified School District

Drafting - Math - Bret Harte High School District

Architecture - Fine Arts

ROP CAD – Computer Literacy

NO

22 Schools out of 30 did not have cross-curricular credit in their Industrial Education department.

APPENDIX B: DESIGN DRAFTING
USING AUTOCAD SOFTWARE AS A TOOL
FOR HIGH SCHOOL STUDENTS

BY WILLIAM BROWN

TABLE OF CONTENTS

Chapter One – Setting Up Your Drawing Area Using Coordinates

Chapter Two – Patterns and Templates

Chapter Three – Orthographic Projections

Chapter Four – Dimensioning to ANSI Y14-5M Standards

Chapter Five – Sectional Views

Chapter Six – General Notes

Chapter Seven – Auxiliary Views

Chapter Eight – Working Drawings

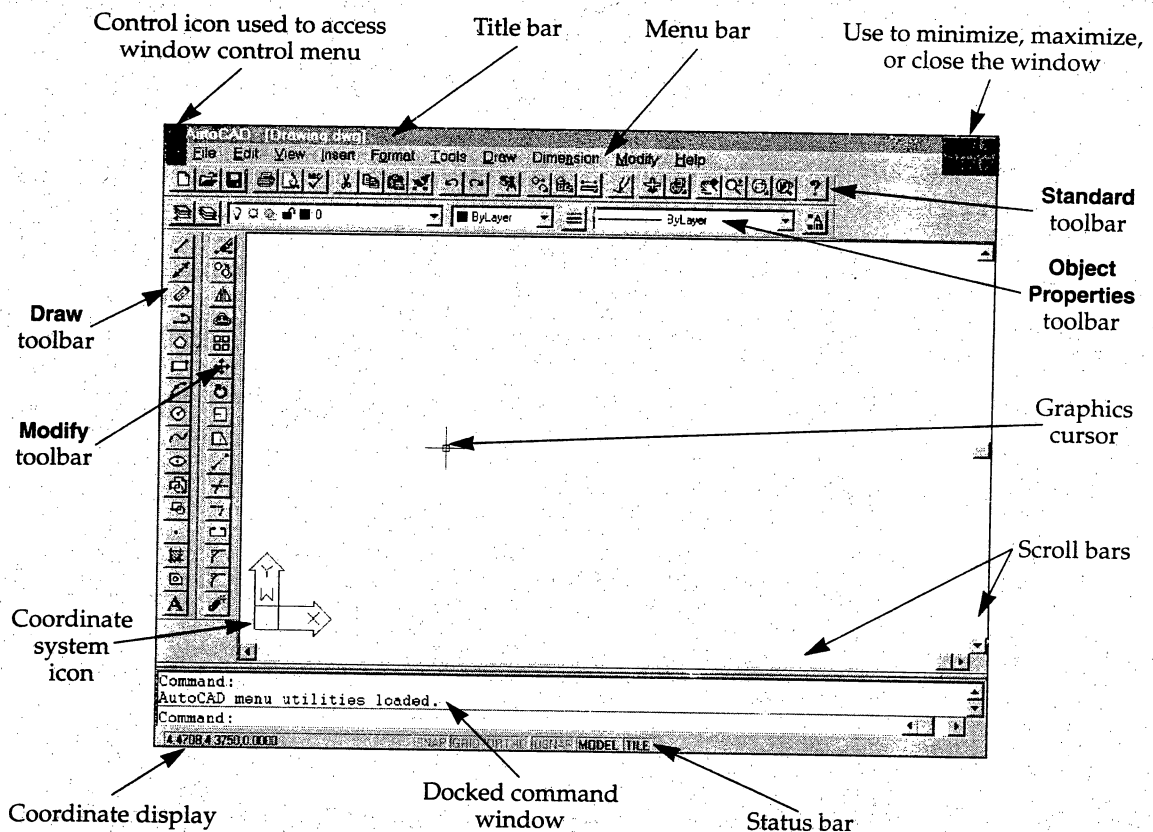
Chapter Nine – Engineering Change Orders

Chapter Ten – Design Engineering Using AutoCAD

CHAPTER ONE

SETTING UP YOUR DRAWING AREA USING COORDINATES

The standard AutoCAD graphics window.



Chapter One

Setting Up Your Drawing Area Using Coordinates

OBJECTIVES:

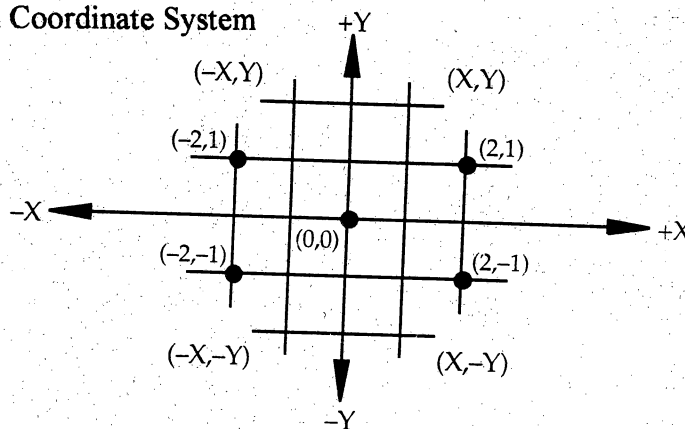
Upon completion of Chapter One, student will be able to:

- Utilize the Cartesian Coordinate System in AutoCAD.
- Apply the concept of “scale” to drawing setup.
- Differentiate between the absolute, relative, and polar coordinate systems in AutoCAD.
- Identify paper sizes by ANSI Y14.1 standards.
- Draw parts in AutoCAD that require scaling up and/or require scaling down.
- Convert metric (millimeter) sizes to (decimal) inch sizes.

SETTING UP YOUR DRAWING AREA – USING COORDINATES

The drawing screen in AutoCAD uses the Cartesian coordinate system (the X-Y axis) as a screen reference. If you move your mouse around the screen, you will notice a pair of numbers moving. These are your coordinates. Notice as you move your mouse horizontally to the right the first number gets bigger. That is your X-coordinate. Notice as you move your mouse vertically-up the second number gets bigger. That is your Y-coordinate.

Figure 4-12. The Cartesian Coordinate System



When using AutoCAD, the origin (0,0) is usually at the lower-left corner of the drawing. This point also coincides with the lower-left corner of the drawing limits. This setup places all points in the upper-right quadrant where both X and Y coordinate values are positive, Figure 4-13. Methods of establishing points in the Cartesian coordinate system include absolute coordinates, relative coordinates, and polar coordinates.

To set a paper size with a horizontal distance of 17 inches and a vertical distance of 11 inches, the first point on the paper would be 0,0 and the second point would be 17,11 (the top-right corner). There are three ways of using the Cartesian coordinate system to input information in AutoCAD. You can use the absolute coordinate system,

the relative coordinate system, or the polar coordinate system. For the purposes of this class, will work in the first quadrant, which is the upper right quarter of the axis system.

See Figure 4-12 and Figure 4 -13.

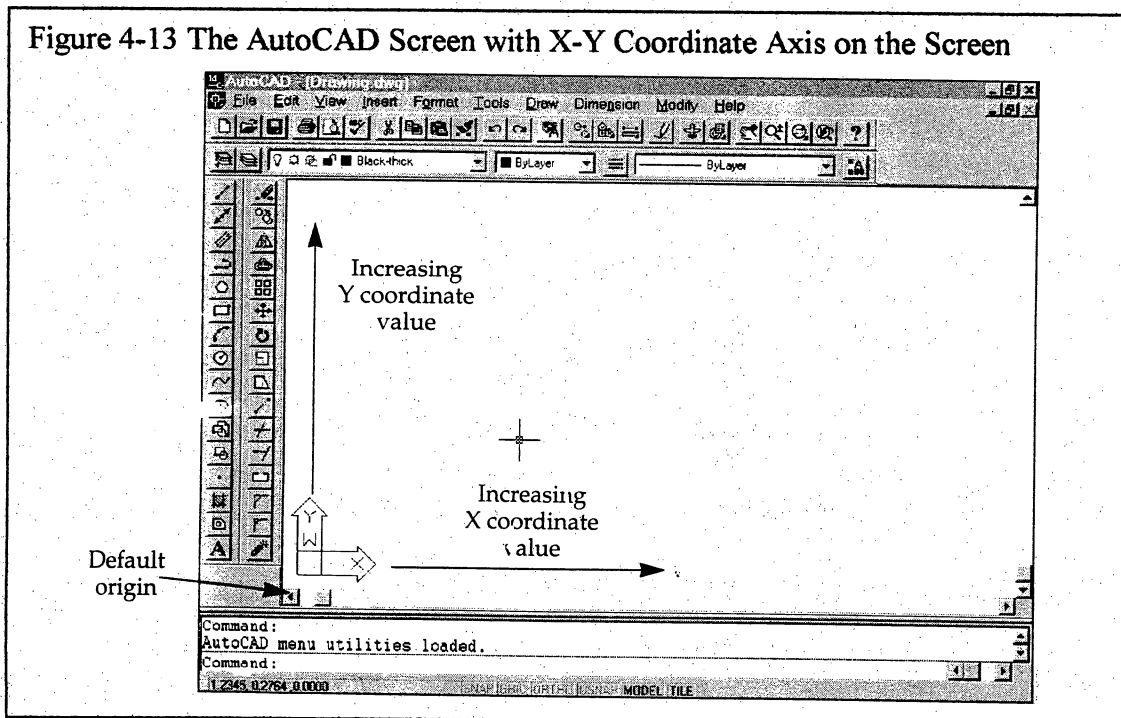
Do Exercise 4-1 ABSOLUTE COORDINATES

Do Exercise 4-2 RELATIVE COORDINATES

Do Exercise 4-3 POLAR COORDINATES

(If the part you are drawing looks strange, check the command line to see if you forgot an @ sign or a comma).

Figure 4-13 The AutoCAD Screen with X-Y Coordinate Axis on the Screen



There are several sizes of paper. They are designated by a letter (A-size, B-size...F-size) in inch units and a number (A0, A1, A2, A3, A4) in metric units. See Figure 66 and Figure 2-5.

Figure 66	Size Designation	Size (in inches)
	A	8 1/2 × 11 (horizontal format) 11 × 8 1/2 (vertical format)
	B	11 × 17
	C	17 × 22
	D	22 × 34
	E	34 × 44
	F	28 × 40
	Size Designation	Size (in millimeters)
	A0	841 × 1189
	A1	594 × 841
	A2	420 × 594
	A3	297 × 420
	A4	210 × 297

In a manual drafting, large objects are reduced in scale to fit on the size paper assigned by the drafter. Likewise, small objects are increased in scale to take up a good portion of the paper. In AutoCAD however, objects are drawn a full-scale. The CAD drafter simply has to set the limits of the drawing to a suitable size to fit the part to be drawn. Once drawn, the object is then printed or plotted to scale.

Do Drawing Problem CC1 Exterior Door (A large part)

Do Drawing Problem CC2 Resistor (A small part)

When drawing in metric, AutoCAD must be tricked into thinking it is drawing in inches. Actually, AutoCAD “thinks” in decimal units not in inches or mm. Here is the strategy. You want to draw a metric part with a length of 200 mm and a height of a 100 mm. You want to plot on a B-size sheet, which is 17 X 11 inches. All AutoCAD recognizes is 17 units by 11 units. 17 X 11 is certainly not big enough for a 200 by 100 part. So you adjust the limits. Multiply 17 by 25 equals 425 and multiply 11 by 25 equals 275. So that is (425,275). Those are your limits! Draw the parts full-size. Notice the part fits with your new limits. When you're finished, you plot the drawing at 1/25 scale.

Do Drawing Problem CC3 TEMPLATE

The objective of this lesson was to introduce the Cartesian Coordinate System and its application to setting up paper sizes (or drawing limits) and scaling drawings up and scaling drawings down. Remember... we always draw the object/part full size: it is the paper size we change (if necessary) to fit the part!

USING ABSOLUTE COORDINATES

Points located using the absolute coordinate system are measured from the origin (0,0). For example, a point with X=4 and Y=2 is measured 4 units horizontally and two units vertically from the origin. If you move your cursor from the origin (0,0) over 4 units and up 2 units, the coordinate display should read (4,2). If it doesn't, press the F6 key. This key is kind of an on/off switch for the coordinate display. To complete Exercise 4-1, give the commands **DRAW**, then **LINE** to draw the eight-sided figure using absolute coordinates.

EXERCISE 4-1 ABSOLUTE COORDINATES

POINT	COORDINATES	POINT	COORDINATES
1	0,0	2	9,0
3	9.5,.5	4	9.5,2
5	0,2	6	0,1.5
7	.25,.5	8	0,0

USING RELATIVE COORDINATES

Relative coordinates are located from the previous position, rather than from the origin. The relationship of points in the Cartesian coordinate system must be clearly understood before beginning with this method. For relative coordinates, the @ symbol must precede your entry. Follow through these commands and relative coordinate point placements as you perform Exercise 4-2.

EXERCISE 4-2 RELATIVE COORDINATES

POINT	COORDINATES	POINT	COORDINATES
1	1,1	2	@9,0
3	@.5,.5	4	@0,1.5
5	@-9.5,0	6	@0,-.5
7	@.25,-1	8	@-.25,-.5

If you forget the @ symbol, the line will go to the absolute coordinate rather than move in relation to the last point you were at. If this happens, **UNDO** the last entry and re-enter the coordinate properly.

POLAR COORDINATES

A point located using polar coordinates is based on the distance from a fixed point at a given angle. When using AutoCAD, a polar coordinate point is determined by distance and angle measured from the previous point, not the origin (0,0). It is much like a relative coordinate. The angular values used for the polar coordinate has a format that looks like this: @4.2<30. This command will make a line 4.2 inches long at an angle of 30 degrees. Zero degrees is at 3 o'clock and the angles measure counter clockwise. Follow these commands and polar coordinate point placements as you perform Exercise 4-3.

EXERCISE 4-3 POLAR COORDINATES

POINT	COORDINATES	POINT	COORDINATES
1	1,1	2	@9<0
3	@.7<45	4	@4.5<90
5	@4.5<180	6	@1.25<225
7	@.75<270	8	1,1

If you forget the @ symbol or < sign, the command line will tell you an improper command was attempted and to re-enter the coordinate.

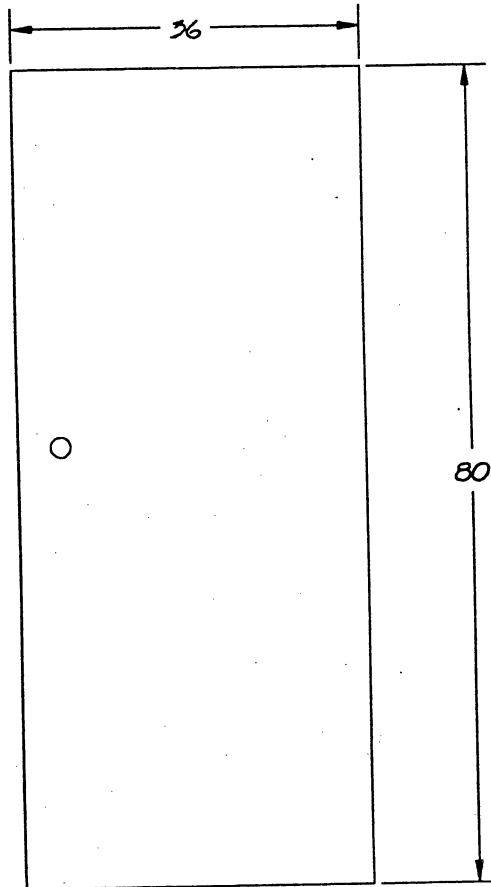
PROBLEM CCI
EXTERIOR DOOR

DRAW FULL SCALE
USE A-SIZE PAPER

HOW MUCH WILL YOU
HAVE TO SCALE UP THE
A-SIZE PAPER TO FIT THE
DOOR?

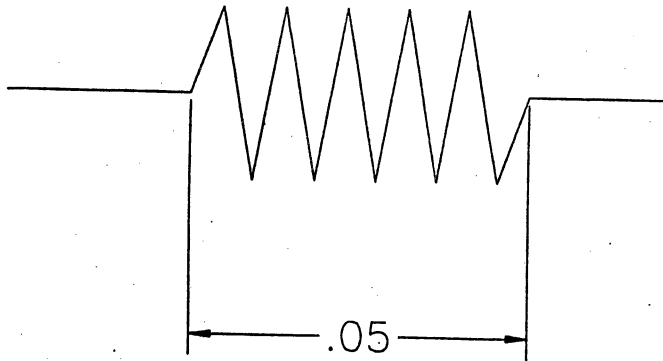
PLOT TO SCALE

USE CARTESIAN COORDINATE
TO DRAW THE DOOR. PLACE
DOORKNOB TOWARD CENTER.



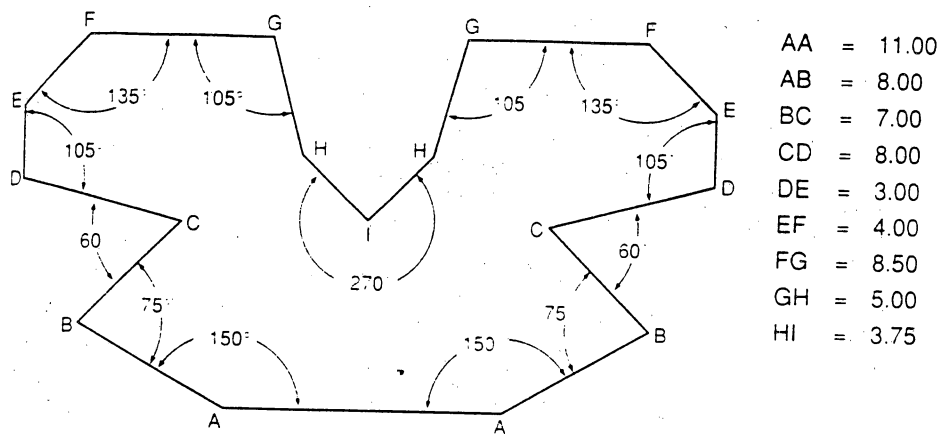
DRAWING PROBLEM CC2 RESISTOR

RESISTOR 43
120K OHMS



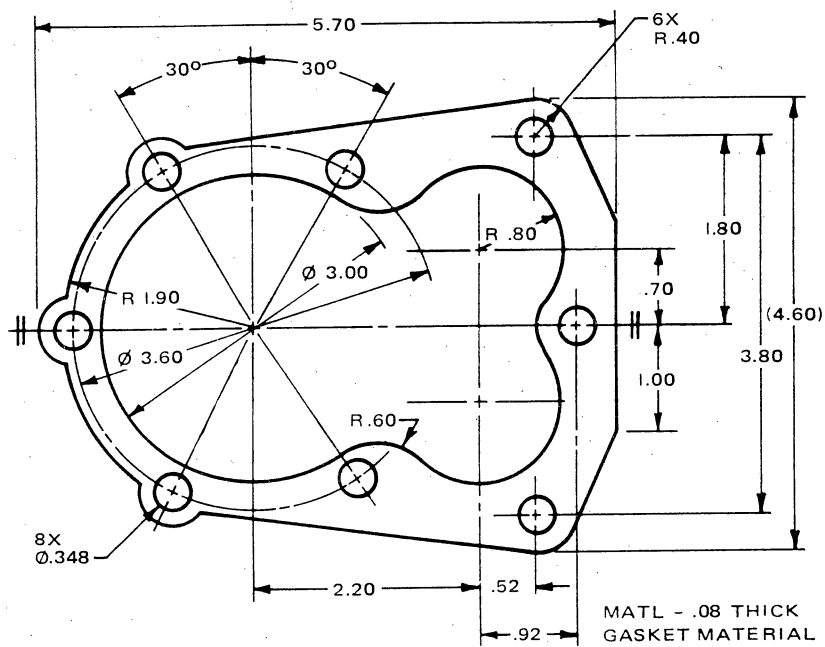
DRAW THE RESISTOR FULL SIZE. PLOT ON A-SIZE PAPER SO THE PART TAKES UP A GOOD PORTION OF THE SHEET. YOU WILL HAVE TO REDUCE THE SIZE OF YOUR LIMITS, THEN PLOT BIGGER.

DRAWING PROBLEM CC3 TEMPLATE



CHAPTER TWO

PATTERNS AND TEMPLATES



Chapter Two

Patterns and Templates

OBJECTIVES:

Upon completion of Chapter Two, student will be able to:

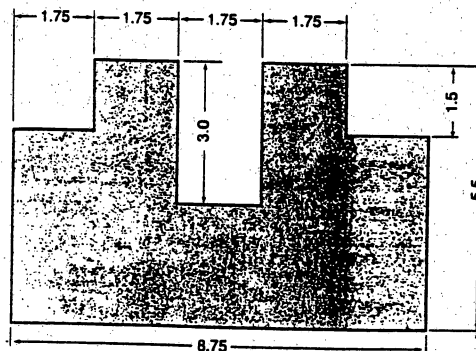
- Use the strategy of offsetting to layout parts.
- Draw parts in AutoCAD that are circular in nature.
- Apply the concept of “scale” to drawing setup.
- Identify metric drawing problems and adjust drawing set-up strategy to accommodate metric measurement.
- Visualize metric units of length via estimation.
- Identify paper sizes by ANSI Y14.1 standards.
- Draw parts in AutoCAD that require scaling up and/or require scaling down.
- Convert metric (millimeter) sizes to (decimal) inch sizes.
- Utilize additional AutoCAD commands.
- Use construction lines in drawing setup.
- Follow directions given in technical and/or mathematical vocabulary.

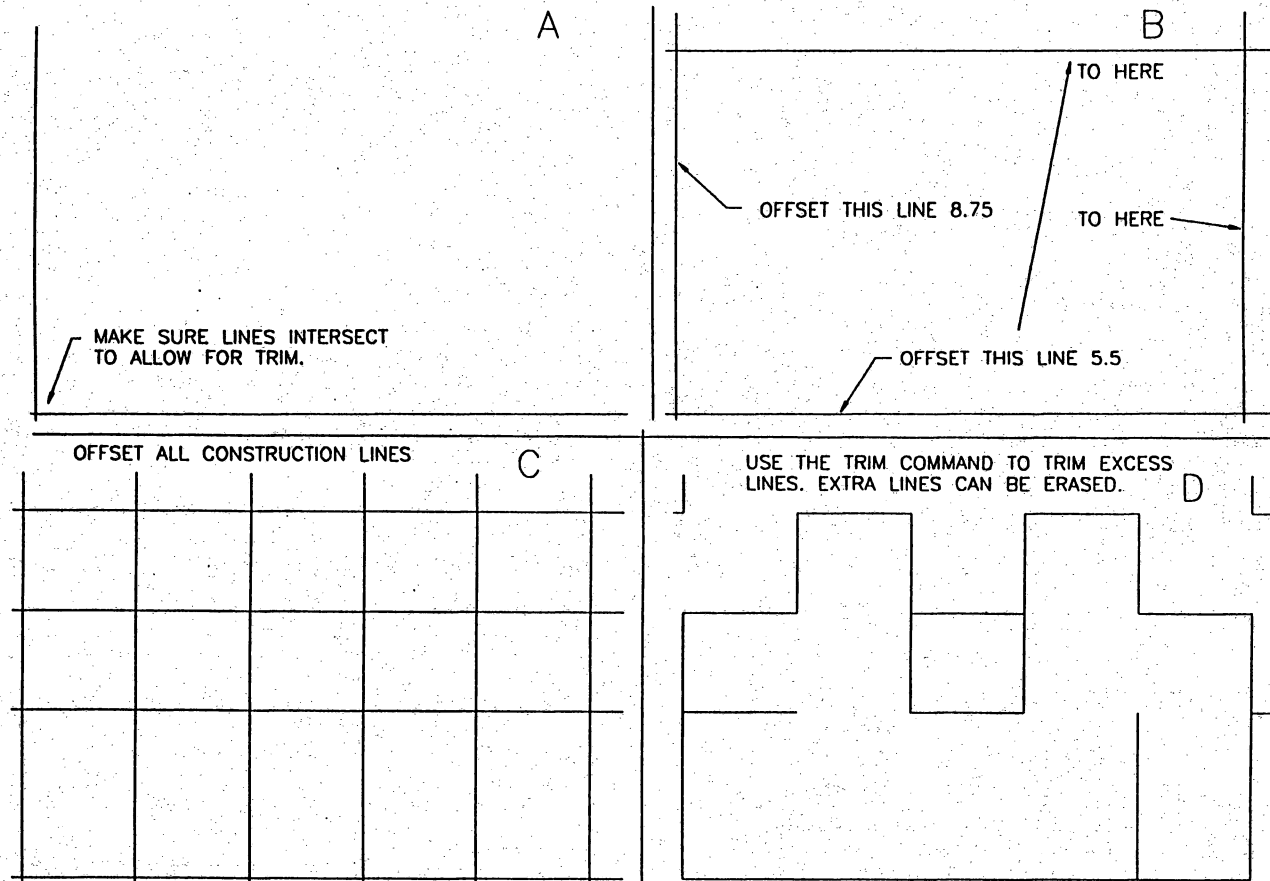
PATTERNS AND TEMPLATES

Frequently it is necessary for the drafter to create drawings in one view. Electrical drawings, patterns, templates, jigs, gaskets are just some of the drawings created in one view. The process of laying out a drawing can be quite different using AutoCAD than using the board. Parts drawn in AutoCAD are drawn full size and plotted to scale, whereas on the board parts are drawn to scale immediately.

Setup your limits for a B-size sheet. Remember your lower left corner is (0,0) then (X,Y) is your top right corner or sheet size. We will not have a title block on this drawing. You will start with a full-scale template (Figure 3-64).

The strategy is to start with two intersecting perpendicular lines (A). Start close to the left side with your vertical line and close to the bottom with your horizontal line. Make sure they intersect in the bottom left corner. Offset the vertical line 8.75" to the right and offset the horizontal line 5.5" up (B). The Template is now "boxed-in". Continue the offset process to create construction lines for the Template (C). Use the trim command to eliminate unwanted parts of the construction lines (D). Any extra lines that you could not trim to get rid of (because there was no longer an intersection) can simply be erased. How does it look? Do not add dimensions. Plot full scale on B-size paper.





Patterns with Circles

Many patterns and templates are designed with a series of circles. Generally many individual parts make-up a larger part. The smaller parts are held together with some kind of fastener like a bolt, screw, rivet, pin, or stud. The parts must be properly aligned when connected together to allow for proper functioning of the part. The size and location of the holes is critical!

When setting up a circular pattern or template, we will layout center-lines (locations) for the holes. When all the center-lines are drawn, we will place our circles at the center line intersections. Trimming and erasing will come afterward.

The first part you are going to draw is a carburetor gasket. It goes between two halves of a carburetor's casing. Bolts go through the top casing, then the gasket, then the bottom casing. The gasket is probably made of a cardboard-like material and functions to seal the two metal casings.

PROBLEM PT2 Carburetor Gasket

Set your limits for B-size paper. Draw a horizontal and vertical line through the middle of your paper. The intersection of these lines will be the center of your part (A). Using the offset command, create the six center-points (B). These will be the locations of the circles and partial circles. Draw the six inner circles using OSNAPS to locate perfectly (C). The rest of the drawing is a series of arcs. Although AutoCAD has a command called "ARC", it is not the best command for this drawing. You are going to draw the arcs as full circles (D), then trim them (E). If you do not use OSNAPS on each

circle, trimming will not work! Now your center-lines are probably a bit sloppy and do not meet ANSI standards for center lines. Erase the center-lines (not the circles or arcs!).

Set **DIMCEN** at **-.09**. Type **DIM** then **enter**. Type **CE** then **enter**. The command line will prompt you to choose a circle or arc. Pick one! Hit **enter**. Pick another... This is a much easier process than adjusting pre-made center lines within the circle. Fillet as assigned. The drawing should look like (F).

Use the same strategy to do:

PROBLEM PT3 Angle Bracket

PROBLEM PT4 Identification Plate

PROBLEM PT2 CARBURETOR GASKET

(See page 8 for step-by-step instructions)

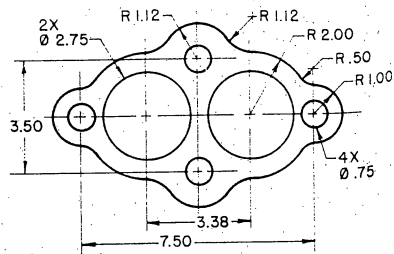


Fig. 3-96 **CAD2** Carburetor gasket.

PROBLEM PT3 ANGLE BRACKET

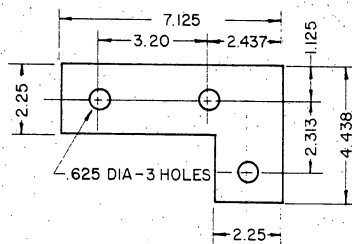


Fig. 3-85 **CAD1** Angle bracket.

PROBLEM PT4 IDENTIFICATION PLATE

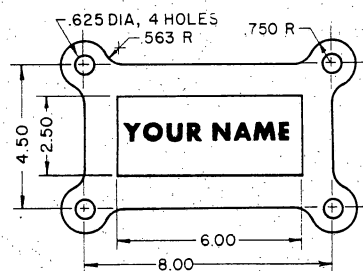
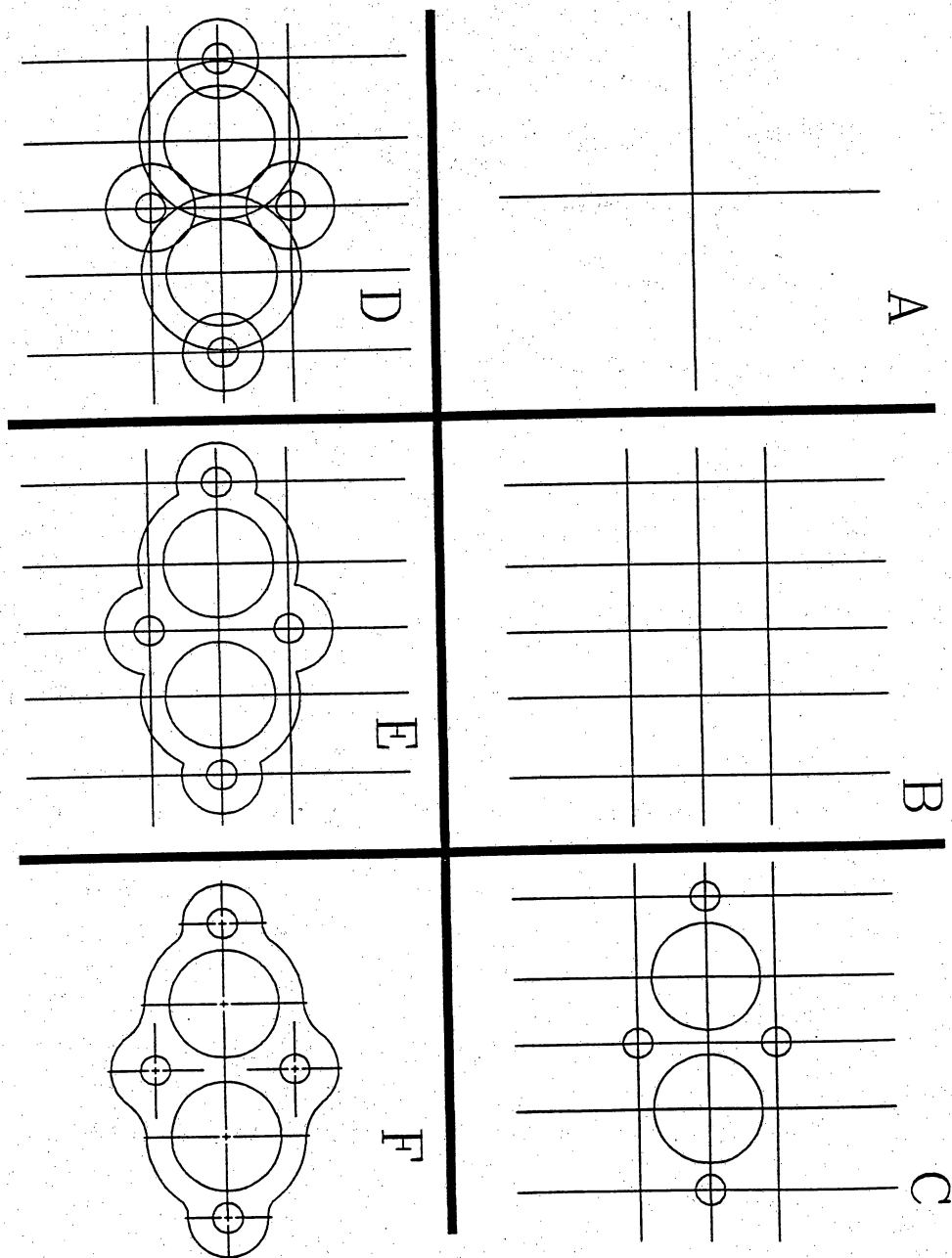


Fig. 3-88 **CAD1** Identification plate.

SEQUENCE FOR CREATING CARBURETOR GASKET



PROBLEM PT5 Head Gasket

Now you will do a metric drawing of a Head Gasket. You will plot on B-size paper. Notice the size of the “C” circle...30mm radius. You will have to adjust your limits to accommodate the metric sizes. Check your new limits. Are they appropriate to fit the Head Gasket? If so, you are ready to start. If not, you will have to scale the limits up or down to make a better fit.

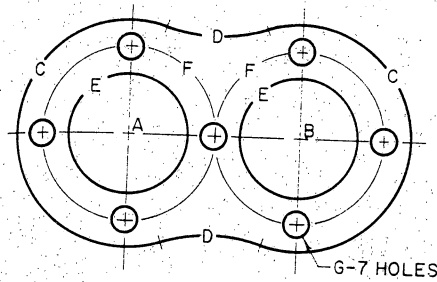
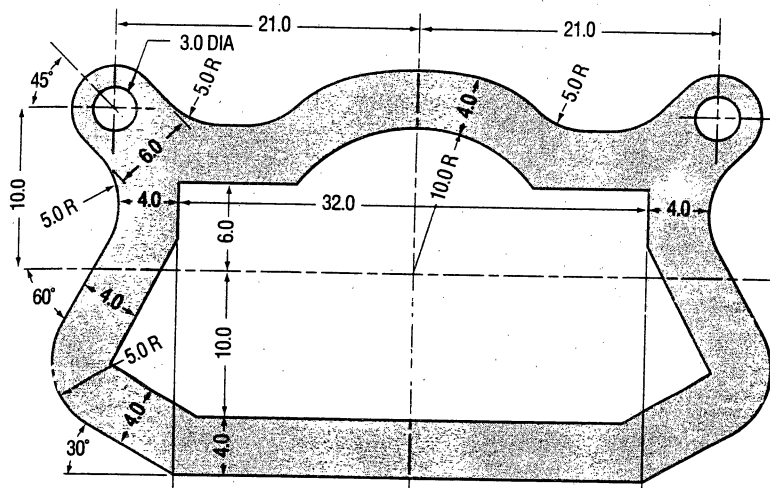


Fig. 3-97 *CAD2* Head gasket. Use metric scale. The distance between center points A and B is 45.50 mm. Radius of arc C is 30 mm. Radius of arc D is 43 mm. Diameter of hole E is 32 mm. Diameter of circle F is 45.50 mm. Holes labeled G have a diameter of 7 mm. Scale: as assigned.

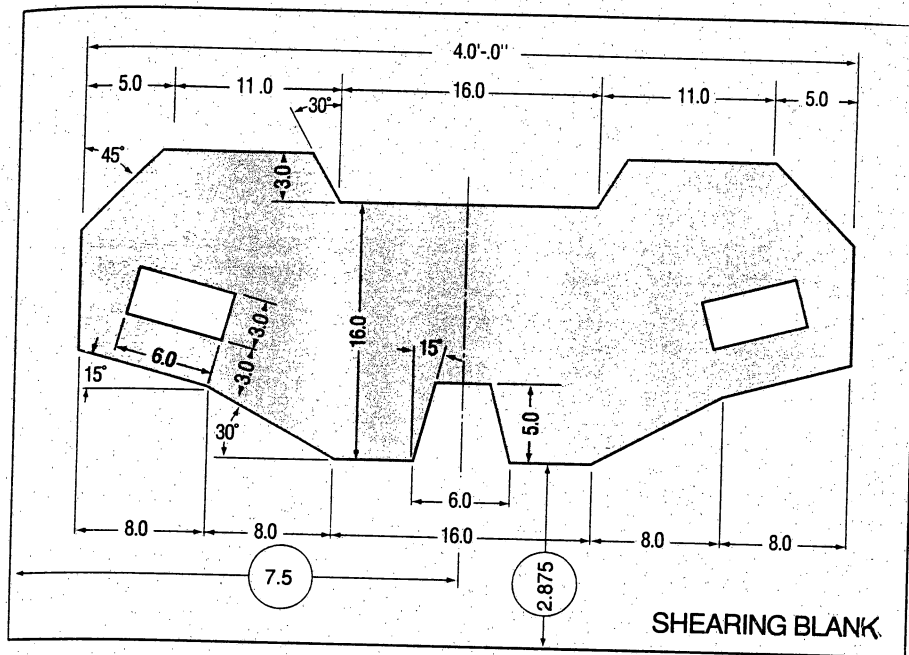
PROBLEM PT6 Cushioning Base

Draw the Cushioning Base on B-size paper. Note the sizes are in decimal inches but the part is far too large to fit on the B-size sheet full size. You need to increase the scale of your drawing sheet to allow for a proper fit. Common scales are 2X, 4X, 8X. Choose the appropriate scale and adjust your limits. Draw the part full size. All done? Now you will add a title block to your drawing. There is a pre-made B-size title block in the "SAMPLE" subdirectory in AutoCAD. Go to **BLOCKS, INSERT, FILE....** go to the SAMPLE subdirectory and double-click on the *Adesk_b.dwg* file. Insertion point will be 0,0 and the scale will be whatever amount you scaled up your limits. Rotation angle is 0. Pretty cool eh? Plot to scale (the reciprocal of what you scaled the drawing up at... $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ etc.).

CUSHIONING BASE

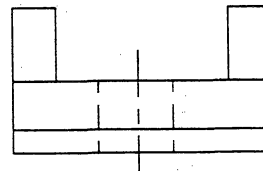
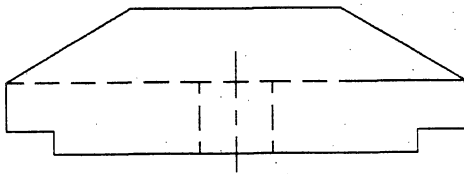
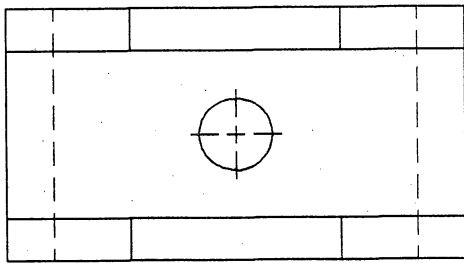


PROBLEM PT7 SHEARING BLANK



CHAPTER THREE

ORTHOGRAPHIC PROJECTIONS



Chapter 3

Orthographic Projections

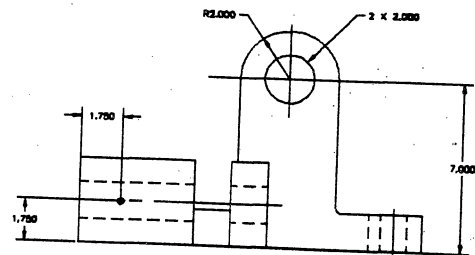
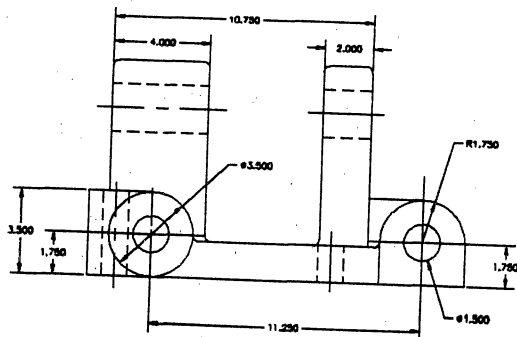
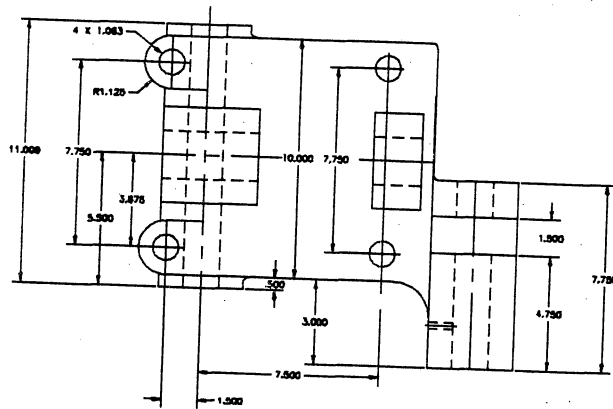
OBJECTIVES:

- Upon completion of Chapter Three, student will be able to:
- Identify and select the various views of an object.
- Determine the number of views needed to describe fully the shape and size of an object.
- Develop a multiview drawing/orthographic projection, utilizing AutoCAD as a tool, to industry standards.
- Place necessary hidden lines on views (for clarity).
- Demonstrate awareness of industry standards through research of technical literature.

CHAPTER FOUR

DIMENSIONING TO ANSI Y14-5M STANDARDS

NOTE: UNLESS SPECIFIED
1. ALL FILLETS & ROUNDS R.250
2. MATERIAL: CAST IRON
3. ALL DIMENSIONS IN INCHES



Chapter Four

Dimensioning

To ANSI Y14-5M Standards

OBJECTIVES:

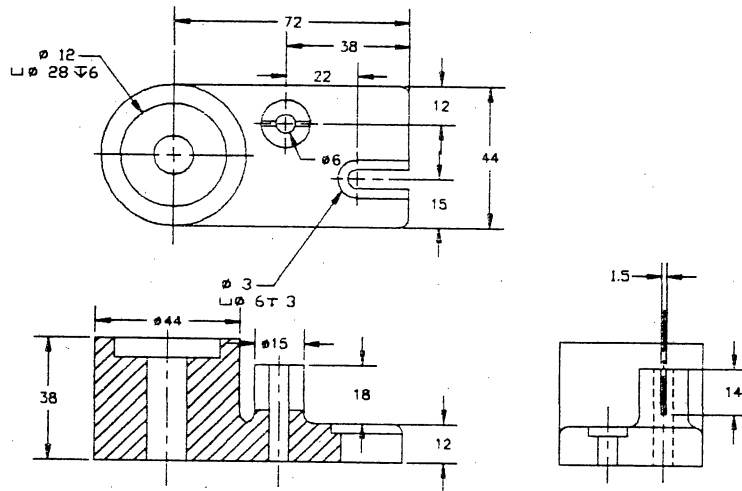
Upon completion of Chapter Four, student will be able to:

- Apply measurements to technical drawings.
- Use ANSI Y14-5M standards for dimensions and notes.
- Differentiate between size dimensions and location dimensions.
- Dimension a part in decimal inch and/or metric.
- Utilize AutoCAD commands to apply dimensions.
- Demonstrate awareness of ANSI Y14-5M standards through research of technical literature.

CHAPTER FIVE

SECTIONAL VIEWS

- NOTES:
 1. DIMENSIONS IN MILLIMETERS
 2. MATERIAL: CAST IRON
 3. UNLESS NOTED ALL UNMARKED RADII R3



Chapter Five

Sectional Views

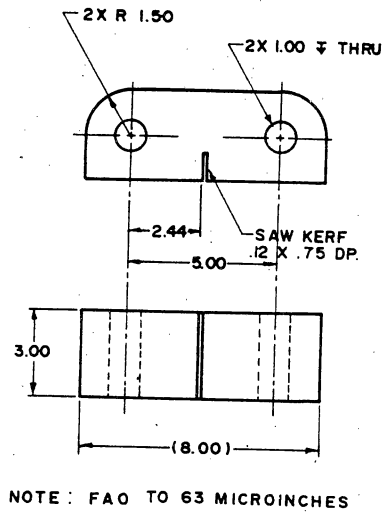
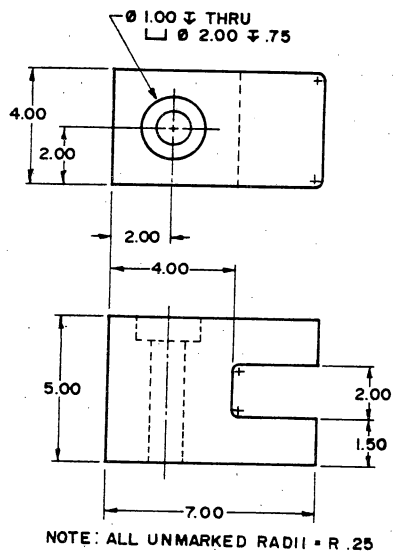
OBJECTIVES:

Upon completion of Chapter Five, student will be able to:

- Select the appropriate type of sectional view to show a hidden feature of a part.
- Show ribs, webs, and fasteners, and similar features properly when the cutting plane passes through them.
- Rotate certain features into the cutting plane.
- Utilize AutoCAD commands to apply section materials.
- Demonstrate awareness industry standards applying to sectioning, through research of technical literature.

CHAPTER SIX

DRAWING NOTES



Notes on drawings improve communication

Chapter Six

Drawing Notes

OBJECTIVES:

Upon completion of this chapter, you will be able to:

- Apply notes on drawings to industry standards.
- Improve communication techniques using technical language.
- Differentiate between general notes and detail notes, and when to apply each.
- Research technical literature involving notation.

NOTES ON DRAWINGS

A good drawing and may be defined as one that contains all of the information required by the various design and manufacturing people who use it in producing the subject part. In most of this information can be conveyed graphically, using standard dimensioning practices. However, it is not uncommon to encounter a situation in which all of the needed information cannot be communicated graphically. In these cases, **NOTES** are used to communicate or clarify the designer's intent.

Notes are brief, carefully worded statements placed on drawings to convey information not covered or not adequately explained using graphics. Notes should be clearly worded so as to allow only one correct interpretation.

There are no ANSI standards specifically governing the use of notes on technical drawings. However, several rules of a general nature should be observed. These rules apply to both general notes and more specific detailed notes.

Two basic types of notes are used on technical drawings: **general notes** and **detailed notes**.

General notes are broad items of information which have a job or project-wide application rather than relating to just one single element of a project or part. General notes are usually placed immediately above the title block on the drawing sheet and numbered sequentially.

Information placed in general notes includes such characteristics of a product as finish specifications; standard sizes of fillets, rounds, and radii; heat treatment

specifications; cleaning instructions; general tolerancing data; hardness testing instructions; and stamping specifications.

Detailed notes are specific notes that pertain to one particular element or characteristic of a part. They are placed as near as possible to the characteristic to which they apply, and are connected using a leader line.

Detailed notes should not be placed on views. Detailed notes also should never be superimposed over other data such as dimensions, lines, or symbols. Use your common sense on placement of notes when text/lettering space is at a premium.

A number of specifications should be observed when writing notes. Proper lettering height is .250 inch titles such as general notes, and 3/16 inch for actual notes. Spacing between lines of the same note should be .0625. Notes should be limited to four to six words per line. Avoid a long line in a notes followed by one short line. Notes should be expressed in the present tense. Notes should be positioned horizontally on the drawing. The left end of all lines of a note should be in alignment, except when an opening statement applies to several succeeding incomplete phrases. Abbreviated may be used if there is no sacrifice in clarity. Do not specify fabrication operations (e.g., DRILL, REAM, TAP, PUNCH, or BORE). The configuration, surface finish and/or tolerance should permit **MANUFACTURING** to establish the type of operation. After all, that is their expertise, NOT YOURS!

DEFINITIONS

General notes. General notes are those which apply to the drawing in general and would become repetitive if placed at each point of application.

Indexed notes. The use of Delta " Δ " notes are those which apply to specific areas of the drawing or parts list in several locations and are cross-referenced by an index symbol to the general notes.

Local notes. Local notes are those which apply directly to a particular portion of a drawing, indicating local characteristics.

SEE THE PAGES AT THE END OF THIS CHAPTER (FROM THE DRAWING REQUIREMENTS MANUAL) FOR MORE SPECIFIC INFORMATION ON THE APPLICATION OF NOTES TO YOUR DRAWING.

Placing Text on Drawings Using AutoCAD

Words and notes on drawings have traditionally been added by hand lettering. This is a slow, time-consuming task. Computer-aided drafting programs have reduced the tedious nature of adding notes to a drawing. In computer-aided drafting, lettering is referred to as **text**.

Company standards often dictate how text appears on a drawing. The minimum recommended text height on engineering drawings is .125". All dimension numbers, notes, and other text information should be the same height. Titles, subtitles, captions, revision information, and drawing numbers can be .188" to .25". Many companies specify a .188 or 5/32" (5mm) lettering height for standard text. These text sizes are easy to read even after the drawing is reduced.

Scale Factors for Text Height

Scale factors in text height should be determined before beginning a drawing, and are best incorporated as values within your template drawing files. The scale factor is multiplied by the desired plotted text height of the AutoCAD text height. The scale factor is always a reciprocal of the drawing's scale.

For example:

You will draw a car at scale of one inch equals one foot. That makes the scale 1/12. Your text needs to be 12 times larger than the size it will be plotted at. So .125 text

would be set at a text height of $.125 \times 12 = 1.5"$. Of course, the drawing will be plotted at 1/12 size, bringing the text-height down to normal size.

You will draw pen cap at 8X size. Your text needs to be 1/8 the size it will be plotted at. So, .125 text would be set at a text height of $.125 \times 1/8 = 1/64"$. Of course, the drawing will be plotted at 8 times size, bringing the text-height up to normal size.

You will draw the floor plan of a home. The scale will be $1/4" = 1'0"$. That makes the scale $1" = 4'0"$. That makes the scale $1" = 48"$ or 1/48 size. What text height setting will you use for an output text height of .125 inches? Did you get six inches for an answer?

Fonts

A font is a particular letter face design. The TXT font is the AutoCAD default. The .TXT font has a rather rugged appearance and may not be the best choice for your application, even though the .TXT font requires less time to regenerate than other fonts. The Romans (roman simplex) font is smoother. It closely duplicates the single stroke gothic lettering that has long been the standard for most drafting. The complex and triplex fonts are multi-stroke fonts for drawing titles and subtitles. The Gothic and italic fonts are ornamental styles. In addition, AutoCAD provides several standard symbol fonts.

Special characters

Control Code	Description	Symbol
%%D	Degrees Symbol	°
%%P	Plus/Minus sign	±
%%C	Diameter Symbol	∅

In order to add the note ∅2.75, the control sequence %%C2.75 is used.

Decimal Units – Decimal Inch vs. Metric (mm)

There are standards for placing zeros in front of decimal places when dimensioning or applying notes. When working in metric, sizes under one mm. require a zero to the left of the decimal place. For example: three tenths of a millimeter is written 0.3 and 12 hundredths of a millimeter is written 0.12. AutoCAD's default setting should give dimensions this way.

Editing Text

Although it is recommended that you enter text as carefully as possible initially, there are times when you must revise text. The following techniques can be used to help edit text with the **DDEDIT** command. Choose **EDIT**, **DDEDIT**, now select the text you want to change. Do you notice it in the **edit text** box? You may now make changes just as you do in a word processor. **ENTER**. Notice the changes have been made to the text.

N1

Use the **MTEXT** command to type the following text using a text style with Romans font and .125 text height. The heading text height is .25. Check your spelling. Save the drawing as P8-4.

NOTES:

1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. REMOVE ALL BURRS AND SHARP EDGES.

CASTING NOTES UNLESS OTHERWISE SPECIFIED:

1. .31 WALL THICKNESS.
2. R.12 FILLETS.
3. R.06 ROUNDS.
4. 1.5°-3.0° DRAFT.
5. TOLERANCES:
± 1° ANGULAR
± .03 TWO PLACE DIMENSIONS.
6. PROVIDE .12 THK MACHINING STOCK ON ALL MACHINE SURFACES.

N2

Use the **MTEXT** command to type the following text using a text style with Stylus BT font and .125 text height. The heading text height is .188. After typing the text exactly as shown, edit the text with the following changes:

- A. Change the \ in item 7 to 1/2.
- B. Change the [in item 8 to 1.
- C. Change the 1/2 in item 8 to 3/4
- D. Change the ^ in item 10 to a degree symbol.
- E. Check your spelling on the text after making the change.
- F. Save as drawing P8-5.

COMMON FRAMING NOTES:

1. ALL FRAMING LUMBER TO BE DFL #2 OR BETTER.
2. ALL HEATED WALLS @ HEATED LIVING AREAS TO BE 2 X 6 @ 24" OC.
3. ALL EXTERIOR HEADERS TO BE 2-2 X 12 UNLESS NOTED, W/ 2" RIGID INSULATION BACKING UNLESS NOTED.
4. ALL SHEAR PANELS TO BE 1/2" CDX PLY W/ 8d @ 4" OC @ EDGE, HDRS, & BLOCKING AND 8d @ 8" OC @ FIELD UNLESS NOTED.
5. ALL METAL CONNECTORS TO BE SIMPSON CO. OR EQUAL.
6. ALL TRUSSES TO BE 24" OC. SUBMIT TRUSS CALCS TO BUILDING DEPT. PRIOR TO ERECTION.
7. PLYWOOD ROOF SHEATHING TO BE \ STD GRADE 32/16 PLY LAID PERP TO RAFTERS. NAIL W/ 8d @ 6" OC @ EDGES AND 12" OC @ FIELD.

ASSIGNMENT N3

Use a polyline for the border. Research proper text heights for a parts list in the Drawing Requirements Manual.

Draw a small parts list (similar to the one shown below) connected to your C-size prototype title block.

- Enter PARTS LIST with a style containing a complex font.
- Enter the other information using text and the **DTEXT** command. Do not exit the **DTEXT** command to start a new line of text.
- Save the drawing as TITLEC-PARTS.
- Record the information about the template in a log.

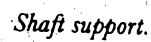
3	HOLDING PINS	12
2	SIDE COVERS	3
1	MAIN HOUSING	1
KEY	DESCRIPTION	QTY

PARTS LIST						
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES AND TOLERANCES FOR: 1 PLACE DIMS: $\pm .1$ 2 PLACE DIMS: $\pm .01$ 3 PLACE DIMS: $\pm .005$ ANGULAR: $\pm 30'$ FRACTIONAL: $\pm .1/32$ FINISH: 125? in.		JANE'S DESIGN				
DR:	SCALE:	DATE:	APPD:			
JANE	FULL	XX-XX-XX				
MATERIAL: MILD STEEL						
NAME: XXX-XXXX						
FIRST USED ON:	SIMILAR TO:	B <table border="1"> <tr> <td>PART NO:</td> <td>REV:</td> </tr> <tr> <td>123-321</td> <td>0</td> </tr> </table>	PART NO:	REV:	123-321	0
PART NO:	REV:					
123-321	0					

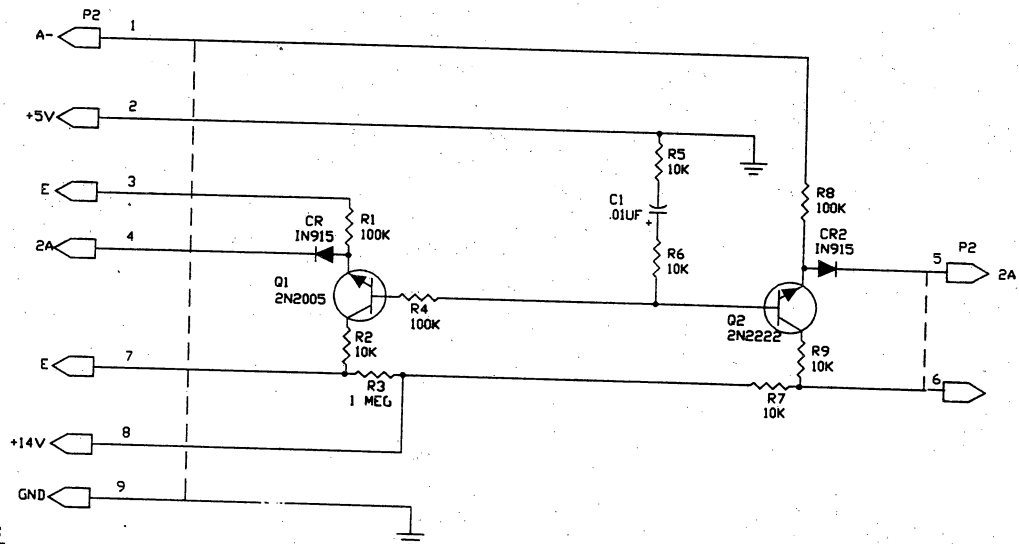
Make a working drawing of the “Guide Bracket”. Apply dimensions and notes to ANSI standards. Plot the drawing on a “B” size sheet.



Make a working drawing of the “Shaft Support”. Apply dimensions and notes to ANSI standards. Plot the drawing on a “B” size sheet.



ASSIGNMENT N6 CONTROLLER SCHEMATIC



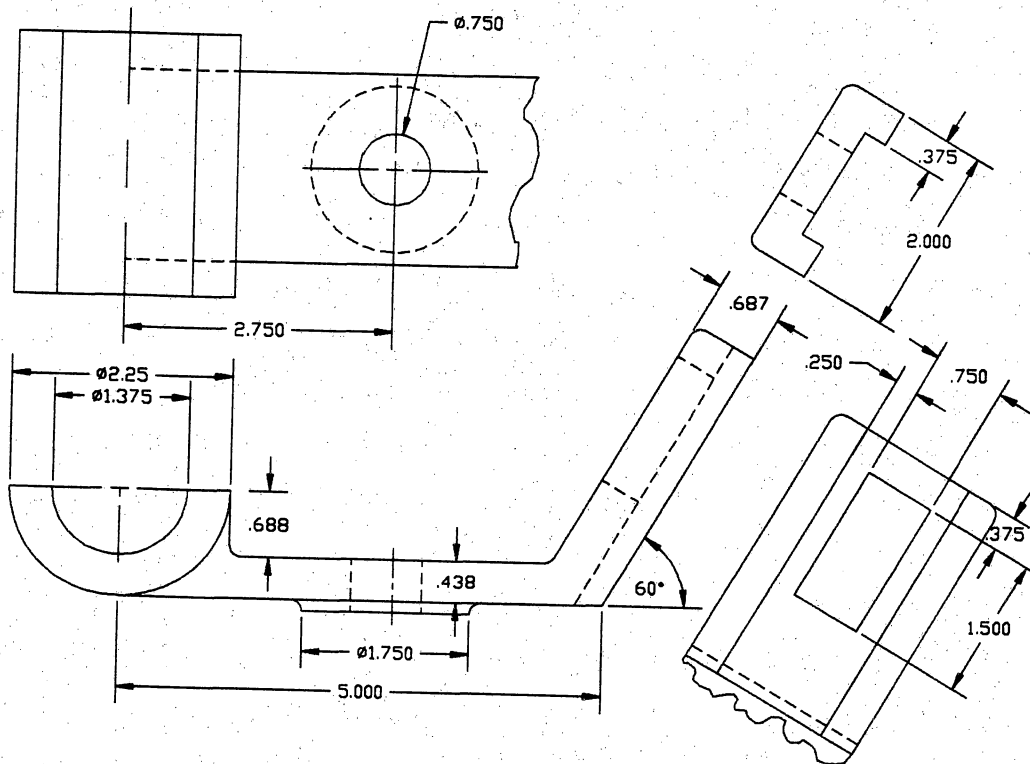
NOTES:

1. INTERPRET ELECTRICAL AND ELECTRONICS DIAGRAMS PER ANSI Y14.15.
2. UNLESS OTHERWISE SPECIFIED:
 RESISTANCE VALUES ARE IN OHMS.
 RESISTANCE TOLERANCE IS 5%.
 RESISTORS ARE 1/4 WATT.
 CAPACITANCE VALUES ARE IN MICROFARADS.
 CAPACITANCE TOLERANCE IS 10%.
 CAPACITOR VOLTAGE RATING IS 20V.
 INDUCTANCE VALUES ARE IN MICROHENRIES.

REFERENCE DESTINATIONS
LAST USED
R9
C1
CR2
Q2

CHAPTER SEVEN

AUXILIARY VIEWS



Chapter Seven

Auxiliary Views

OBJECTIVES:

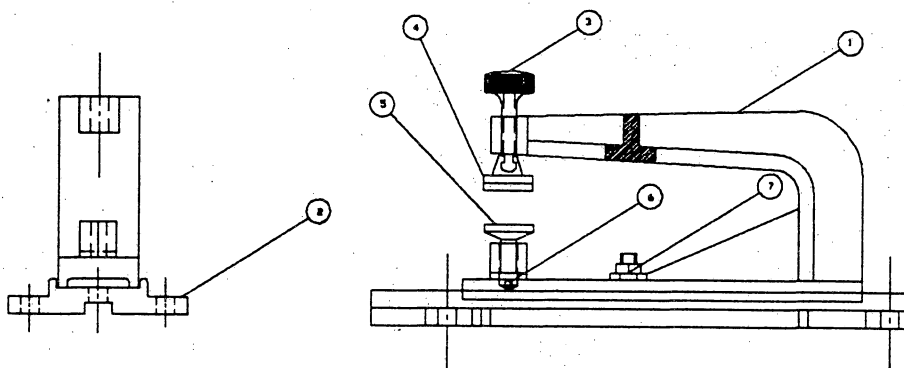
Upon completion of Chapter Seven, student will be able to:

- Develop a primary auxiliary view of an inclined surface.
- Determine when a partial auxiliary view is acceptable and when a complete auxiliary view is required.
- Utilize AutoCAD commands to develop an auxiliary view.
- Demonstrate awareness industry standards regarding auxiliary views, through research of technical literature.
- Apply proper dimensioning techniques to auxiliary views.

CHAPTER EIGHT

WORKING DRAWINGS

REVISION			
ECD	REV	DESCRIPTION	DATE
	A	PRODUCTION RELEASE	5-21-87



BILL OF MATERIALS				
7	BOLT AND HEXNUT	1	STK	.313 X 1.5
6	STEEL BALL	1	STL	.313 DIA
5	SWIVEL BUTTON	1	CRS	1 X 1
4	SWIVEL	1	CRS	1 X .7
3	THUMB SCREW	1	CRS	1 X 1.183
2	BASE	1	CRS	2.75 X 11 X .75
1	HEAD	1	CI	1.625 X 8.5 X 3.313
ITEM	NAME	AMT	MATERIAL	REMARKS

Chapter Eight

Working Drawings

OBJECTIVES:

- Upon completion of Chapter Eight, student will be able to:
- Describe and produce detail drawings, assembly drawings, and assembly working drawings.
- Develop a bill of materials and parts list for a working drawing.
- Apply reference symbols to parts per industry standards.
- Identify the relationship between connecting parts through dimensions and function.
- Complete a challenging working drawing, to industry standards, utilizing AutoCAD as a drawing tool.

CHAPTER NINE

ENGINEERING CHANGE ORDERS (ECO'S)
OR
DRAWING CHANGE PROCEDURES

Chapter Nine

Engineering Change Orders (ECO'S) or Drawing Change Procedures

OBJECTIVES:

Upon completion of Chapter Nine, student will be able to:

- Complete an Engineering Change Order form.
- Identify the process used to generate an ECO.
- Record change orders on an engineering drawing to industry standards.
- Research industry documentation on proper standards to complete an ECO.
- Make appropriate changes to a drawing by following instructions on an ECO form.

Engineering Change Orders (ECO) or Drawing Change Procedure (DCP)

When a drawing needs to be changed from the original release or revision, a document called an Engineering Change Order (ECO) must be created. This chapter will discuss techniques and procedures involved in making revisions requested from an ECO to your engineering drawings.

When a drawing, or set of drawings are created by a design drafter or engineer, the drawing(s) are released to every sector in the company involved in making/producing the part. The initial drawing everybody receives would be Revision A. If the part works fine, everyone is happy and no more revisions need to be generated. Frequently however, parts can be redesigned to better meet their function. This decision to redesign the parts could come from the customer, the manufacturing department, purchasing department, the quality control department, the sales force, or the engineering department. Whoever initiates the change does so by creating an Engineering Change Order (ECO). This ECO basically states what the change should be and why the change(s) is being requested. The ECO only needs to be generated if the drawing has actually been released.

The responsible engineer has the primary responsibility for initiating ECO's or for approving ECO's originated outside the project. On receipt of an approved ECO, the drafting department determines the correct procedure for implementing the change(s). A pre-printed form is used to authorize and record drawing changes. Typing or legible hand lettering is permissible on this form.

Once changes are made to the original revision (A), the drawing now becomes Revision B. Subsequently, if changes are made to revision B, the drawing becomes Revision C... A drawing may have many revisions. Multiple changes (two or more) to the same drawing and incorporated at one time shall be identified by the same revision letter and may be identified on the ECO in numerical sequence and on the field of the drawing enclosed in the revisions symbol balloon as a suffix number.

The following sheets shown ECO's and the procedures that must be followed when generating Engineering Change Orders. Note page 23-7 for placement and format of the Engineering Change Orders on the drawing.

ENGINEERING CHANGE ORDER DWG NO:ECO 1

PRODUCT AFFECTED: Cushioning Base

EFFECTIVE

DATE: July 6, 1998

DOCUMENT AFFECTED: DRAWING NUMBER: PT6

ORIGINATOR: MR. BROWN

DATE: July 1, 1998

NEW REVISION NO. B

DESCRIPTION OF CHANGE:

Part width change from 4.0 to 4.5. Add material toward center of Cushioning Base.

REASON FOR CHANGE: Customer stated need for more interior part coverage from Cushioning Base.

NOTE TO STUDENT: ENGINEERING CHANGE ORDERS CAN BE GENERATED FROM MANUFACTURING (THE PEOPLE WHO MAKE THE PART), QUALITY CONTROL (THE PEOPLE WHO CHECK TO SEE IF THE PART IS MADE TO SPECIFICATIONS OF THE ENGINEERING DRAWINGS), CUSTOMER SERVICE (THE PEOPLE WHO DIRECTLY RESPOND TO THE CUSTOMER'S NEEDS), OR THE VARIOUS ENGINEERS INVOLVED IN THE DESIGN PROCESS OF THE PART.

THE NEW DRAWING, CALLED THE NEW "REVISION", WILL BE COPIED AND DISTRIBUTED TO ALL WHO REQUIRE IT. THE OLD DRAWING RELEASES WILL BE STORED FOR FUTURE REFERENCE. IT IS IMPORTANT THAT NEW PARTS ARE NOT MADE FROM OBSOLETE, OLD DRAWING REVISIONS.

ENGINEERING CHANGE ORDER DWG NO:ECO 2

PRODUCT AFFECTED: Shearing Blank
EFFECTIVE
DATE: July 16, 1998

DOCUMENT AFFECTED: DRAWING NUMBER: PT7
ORIGINATOR: MR. BROWN
DATE: July 4, 1998
NEW REVISION NO. B

DESCRIPTION OF CHANGE:

Change 30 degree angle to 35 degrees.

REASON FOR CHANGE: Change to new year model.

NOTE TO STUDENT: ENGINEERING CHANGE ORDERS CAN BE GENERATED FROM MANUFACTURING (THE PEOPLE WHO MAKE THE PART), QUALITY CONTROL (THE PEOPLE WHO CHECK TO SEE IF THE PART IS MADE TO SPECIFICATIONS OF THE ENGINEERING DRAWINGS), CUSTOMER SERVICE (THE PEOPLE WHO DIRECTLY RESPOND TO THE CUSTOMER'S NEEDS), OR THE VARIOUS ENGINEERS INVOLVED IN THE DESIGN PROCESS OF THE PART.

THE NEW DRAWING, CALLED THE NEW "REVISION", WILL BE COPIED AND DISTRIBUTED TO ALL WHO REQUIRE IT. THE OLD DRAWING RELEASES WILL BE STORED FOR FUTURE REFERENCE. IT IS IMPORTANT THAT NEW PARTS ARE NOT MADE FROM OBSOLETE, OLD DRAWING REVISIONS.

ENGINEERING CHANGE ORDER DWG NO:ECO 3

PRODUCT AFFECTED: Carburetor Gasket

EFFECTIVE

DATE: July 26, 1998

DOCUMENT AFFECTED: DRAWING NUMBER: PT2

ORIGINATOR: MR. BROWN

DATE: July 4, 1998

NEW REVISION NO. B

DESCRIPTION OF CHANGE:

Change location dimension of 3.38 to 4.38 and location dimension of 7.50 to 8.50. Change hole sizes of 2.75 to 3.00 diameter.

REASON FOR CHANGE: Change to new year model.

NOTE TO STUDENT: ENGINEERING CHANGE ORDERS CAN BE GENERATED FROM MANUFACTURING (THE PEOPLE WHO MAKE THE PART), QUALITY CONTROL (THE PEOPLE WHO CHECK TO SEE IF THE PART IS MADE TO SPECIFICATIONS OF THE ENGINEERING DRAWINGS), CUSTOMER SERVICE (THE PEOPLE WHO DIRECTLY RESPOND TO THE CUSTOMER'S NEEDS), OR THE VARIOUS ENGINEERS INVOLVED IN THE DESIGN PROCESS OF THE PART.

THE NEW DRAWING, CALLED THE NEW "REVISION", WILL BE COPIED AND DISTRIBUTED TO ALL WHO REQUIRE IT. THE OLD DRAWING RELEASES WILL BE STORED FOR FUTURE REFERENCE. IT IS IMPORTANT THAT NEW PARTS ARE NOT MADE FROM OBSOLETE, OLD DRAWING REVISIONS.

ENGINEERING CHANGE ORDER DWG NO:ECO 4

PRODUCT AFFECTED: Guide Bracket

EFFECTIVE

DATE: July 7, 1998

DOCUMENT AFFECTED: DRAWING NUMBER: N4

ORIGINATOR: MR. BROWN

DATE: July 2, 1998

NEW REVISION NO. B

DESCRIPTION OF CHANGE:

Change 24 diameter SPOTFACE to 24 CBORE - 3 deep. Change to four ribs.

REASON FOR CHANGE: Part cracking at corners. Larger radii not a design change possibility (customer).

NOTE TO STUDENT: ENGINEERING CHANGE ORDERS CAN BE GENERATED FROM MANUFACTURING (THE PEOPLE WHO MAKE THE PART), QUALITY CONTROL (THE PEOPLE WHO CHECK TO SEE IF THE PART IS MADE TO SPECIFICATIONS OF THE ENGINEERING DRAWINGS), CUSTOMER SERVICE (THE PEOPLE WHO DIRECTLY RESPOND TO THE CUSTOMER'S NEEDS), OR THE VARIOUS ENGINEERS INVOLVED IN THE DESIGN PROCESS OF THE PART.

THE NEW DRAWING, CALLED THE NEW "REVISION", WILL BE COPIED AND DISTRIBUTED TO ALL WHO REQUIRE IT. THE OLD DRAWING RELEASES WILL BE STORED FOR FUTURE REFERENCE. IT IS IMPORTANT THAT NEW PARTS ARE NOT MADE FROM OBSOLETE, OLD DRAWING REVISIONS.

CHAPTER TEN

**DESIGN ENGINEERING
USING AUTOCAD**

Chapter Ten

Design Engineering

Using AutoCAD

OBJECTIVES:

Upon completion of this chapter, you will be able to:

- Use AutoCAD as a design tool to solve problems.
- Apply the concept of associative dimensioning.
- Draw interchangeable parts using current drafting-dimensioning practices.
- Extend your creative attributes in solving engineering problems.
- Effectively communicate your ideas for problem solutions.

Container Design Project

Assignment DE1

Design a box to hold 5 “Technical Drawing” textbooks. Packaging material will be .12 cardboard. You will create a pattern, complete with allowances for bends and tabs. You have latitude with tolerance of box, but you must identify the tolerance with a general note. This is a one-view drawing! Dimensions to .XX. Draw to ANSI standards. You will have to do a little reading on developments.

CAD DRAFTING WORKSTATION ASSIGNMENT DE2

Your Engineering Design Project is to design a Computer-aided Drafting (CAD) workstation. What I am looking for is a table that will incorporate a manual elbow type drafting machine, a CPU, monitor, keyboard, mouse, and printer. I do not want students to have access to the CPU, but I want to be able to access it easily. (Maybe a key-locked door or ?). I want the CPU and monitor to be housed so they are difficult to steal, yet get enough ventilation to work properly. Desktop size should be between 24" X 36" and 36" X 48". No bigger...no smaller. I want two locking drawers; one to hold drawing supplies (not paper), and one CD ROMS and diskettes.

Ease of fabrication would be a plus. It must be able to be disassembled to a reasonable size (for shipping). State what materials and colors you will use.

1. Sketch your idea in isometric or multiview.
2. Keep accurate track of your time (to 15 minute increments). You will be provided materials/forms to do this.
3. You may "borrow" parts of other companies designs to integrate into your own, BUT you may NOT NOT NOT NOT NOTNOT infringe on someone else's design! Ask me if you are not sure. This project should represent **YOUR** **UNIQUE** thoughts and ideas!!
4. You will need a Bill of Materials.

5. Your finished drawing will be a multiview assembly drawing with basic, overall dimensions, perhaps sectioned, to show every detail.
6. A “Description Paper” explaining why you designed the table the way you did.
7. Detail drawings of each part, fully dimensioned, will be your last step. After that, a pictorial drawing can be added.

LANDING VEHICLE FOR PLASMAQUATIC LIQUID

Assignment DE3

Congratulations! You and your design/drafting team have just won a contract to design and build a landing vehicle for plasmaquatic liquid. Plasmaquatic liquid is a space age, high-energy source that is very corrosive, highly explosive and therefore cannot be allowed to spill. Your challenge is to design and build a landing vehicle that will permit a container of plasmaquatic liquid to be dropped from 400 cm. and land on a flat surface without spilling.

Design Requirements

1. Maximum size of "lander" will be determined by the "GO-NO GO" gage. It must fit in the gage without crushing.
2. The landing surface will be concrete.
3. The container for classroom plasmaquatic liquid will be a styro-foam cup. It will be half-filled with plasmaquatic liquid. The container cannot be covered.
4. Provision should be allowed for placing the container in vehicle without any additional fixtures.
5. The only material to be used in constructing the vehicle is doubled durable construction film. (Sample at contract headquarters).
6. All materials to be joined with ticky-tacky glue or ticky-tacky tape.
7. Landing vehicle to have one-inch square launch and handling tab on top.
8. Flight insignia's are optional.

Evaluation:

All entries that pass the drop test without spilling the more than 2 mm of plasmaquatic liquid will be judged for:

1. Neat appearance.
2. Most innovative design.
3. Accuracy of drawings to finished prototype.

BRIDGE DESIGN PROJECT ASSIGNMENT DE4

Congratulations:

You and your design/drafting team have just been awarded a contract to perform preliminary design activities, to prepare working drawings, and to fabricate and erect a structure capable of:

Transporting 340 grams of liquid 600 mm across an open span 525 mm. in distance. The tanker size and shape shall be either a plastic truncated cup with an open top (size: 48 mm base, 80 mm at the open top, and 88 mm. high with a capacity to hold 340 grams of liquid) or aluminum can (size: 60 mm. diameter, 122 mm. high with the capacity to hold 340 grams of liquid).

The construction materials for the structure including columns, beams, and/or girders shall be high strength, durable plastic straws with a size of 196 mm. long and an outside diameter of 7 mm.

A maximum of 30 straws will be allowed for final construction. The beam construction methods shall be:

1. Strips of 6 mm wide drafting tape.
2. Strips of 12 mm wide transparent tape.
3. Non-toxic white glue.
4. Model airplane glue.
5. Plastic straw gussets constructed/fabricated with 1,2,3, or 4 above.

A canopy 120 mm wide, 5 mm. thick, and 600 mm long, made of single strength corrugated cardboard or equal will be provided.

One meter of high strength towing string will be used to move the tanker the required 600 mm across the structure.

Free samples of the above materials will be available at contract headquarters.

Design criteria (restrictions):

1. Must hold the canopy (cover) 140 mm above the track.
2. If a track is used, the sliding track must run the length of the structure to transmit the load across the span.
3. The lower structure members may not be laid side-by-side in either direction as to create a platform effect.
4. Time line for project: 10 hours of class sessions.

You and your design drafting team are to complete the following tasks:

1. Select a company spokesman who act as chief design engineer. He/she will be responsible for final decision-making.
2. Determine the company name and logo design which will be reproduced on the canopy (color may be added).
3. Determined time allocations for various aspects of the project. Components to include:
 - a. Brainstorming.

- b. Research formal.
- c. Materials testing.
- d. Sketching preliminary designs, construction methods, and/or ideas.
- e. Drawing plans.
- f. Construction.
- g. Testing.
- h. Review, evaluation, and conclusions.

Submit information on attached specifications sheet.

- 4. Submit all sketches (pictorial and multi-view).
- 5. Submit a set of working drawings consisting of:
 - a. Layout drawing - showing overall and key dimensions of the structure and location of structural members (single line schematic drawing). Note: this drawing as well as all drawings will be accomplished using AutoCAD as a drawing tool.
 - b. Assembly drawings.
 - c. Design drawing indicating loading diagrams (cross-member load, a truss reactions).
 - d. Notes, notations, and design specifications established by your company.
 - e. Detailed drawings of structural assembly methods and design.
- 6. Construct/erect structural members and structure.
- 7. Provided testing.
- 8. Final (written) report.

BRIDGE DESIGN PROJECT ASSIGNMENT DE4

PROBLEM TITLE

COMPANY NAME

DATE

RESPONSIBILITIES

CHIEF DESIGN ENGINEER

ENGINEER/ DESIGNERS

CAD DRAFTERS

TIME LINE-PLAN

TIME TO NEAREST 600 SECONDS

COMPANY ORGANIZATION

PLAN

ACTUAL

PLANNING

BRAINSTORMING/
RESEARCH

SKETCHING IDEAS

DRAWING PLANS

NOTES/SPECIFICATIONS

CONSTRUCTION/
FABRICATION

TESTING

FINAL REPORT

Super Powered Landing Aeronautics Technology S.P.L.A.T. DE5

A Unit on Surface Developments and Intersections

Surface developments and intersections are drawings that convert two-dimensional, flat objects such as paper, sheet metal, cardboard, etc. into three-dimensional objects. These objects can be geometric shapes such as truncated prisms, cylinders, pyramids, cones, and transition pieces.

As an important application to this unit, students will design, draw, and construct the following design engineering problem:

Given a 24" X 36" sheet of vellum, develop a device, container, or shape using only applied surface development "stretch-outs" that will hold an egg which when dropped from a height of about 65 feet, the egg will not break (or crack). The finished drawing will be plotted on D-size vellum from which the device, container, or shape will be constructed and tested twice.

Ground Rules:

1. Maximum size – 12" X 12" X 12" in the "closed" position.
2. Materials – 24" X 36" D-size vellum, 6" drafting tape for door hinges only, rubber contact glue (for assembly).
3. Passenger to have ingress and egress of 30 seconds or less.
4. A complete detailed drawing of the various parts with dimensions and an assembly drawing of the device is required.

5. No crushed paper may be used. All structural items to be drawn and dimensioned.
6. Time elements: six hours design and layout, color/graphics, and four hours construction and testing.

Students have the opportunity to try for:

- a. Fastest time down.
- b. Slowest time down.
- c. Closest to target.
- d. Furthest from target via: drift or glide
- e. Design criteria (functional design). The device, container, or shape will be released with an underhand thrown motion from a ladder atop of the gym.
- f. Each device, container, or shape will be tested a minimum of two flights.

***NOTE:** Color and graphics to be added to print prior to construction and testing.

Free-standing Structure

Assignment DE6

Congratulations! Your design team has been selected to prepare a working model of a freestanding structure to hold a specific object. The design will involve developing the tallest structure possible to support the object.

Materials provided:

- ❖ Three pieces of plain color paper and one piece of plain white paper for experimental structural development.
- ❖ One bottle of rubber cement.

Object to be supported:

- ❖ Ping Pong ball

The design team will involve two members.

Requirements:

- ❖ No. 1 Develop company name
- ❖ No. 2 Develop company logo
- ❖ No. 3 Each design team member is to develop working drawing sketches of the detailed part and an assembly drawing of the structure. The company name, logo, and sketches are to be submitted to design headquarters prior to receiving the materials to construct the structure. Your design team will have 60 minutes to complete the organizational activities and to experiment with the plain white paper to determine the best structural members for the structure.

- ❖ No. 4 Construction activities will be limited to 80 minutes.
- ❖ No. 5 A structure with object in place must be erected in 10 minutes.
- ❖ No. 6 The structure and object is to be free-standing and is to remain standing for 10 minutes.

Good luck and just as important, good planning, a good design, and good construction!

References

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